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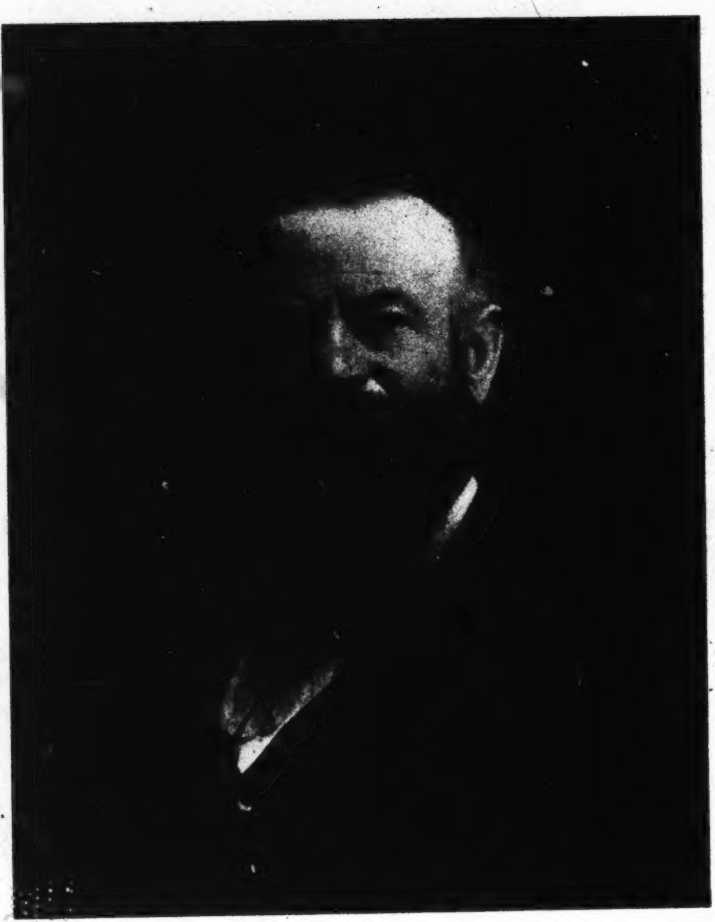

JOHN WESLEY POWELL

RECLAIMING THE ARID WEST

The Story of the United States Reclamation Service

BY

GEORGE WHARTON JAMES

WITH ILLUSTRATIONS

NEW YORK
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1917

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TO

JOHN WESLEY POWELL

The Father of the U. S. Reclamation Service,

Who planned the campaign, trained the first officers, and put confidence into the hearts of the first army of workers in the field of Irrigation

TO

FRANCIS G. NEWLANDS

The Constructive Statesman,

Whose clear-acting legal mind, smoothed the legislative path and made possible congressional action upon this difficult subject

TO

CHARLES D. WALCOTT

The Enthusiastic Organizer,

Who gave up a loved profession that he might devote his genius to the organization of the Reclamation Service

TO

FREDERICK H. NEWELL

The Scientific Leader,

Who, as tireless engineer and administrator did much to draw together the earlier workers of the Reclamation Service

TO

WILLIAM E. SMYTHE

The Eloquent and Convincing Orator,

Who by pen and voice sought the education of the people

TO

GEORGE H. MAXWELL

The Energetic and Tireless Advocate,

Who interested capital and brains in the irrigation of arid lands

TO

ARTHUR POWELL DAVIS

The Practical Engineer,

Whose ability and knowledge have ever counseled the project engineers in their problems

TO

FRANKLIN K. LANE

The Sympathetic Secretary of the Interior,

Whose breadth of mind has visioned the possibilities of this great movement of triumphant democracy and led him to enlarge its plans until now the arid deserts of the western United States are being made to blossom as the rose

TO THESE,

AND TO ALL THE FAITHFUL OFFICERS

At Home and In the Field, who have carried out the great plans of the originator of the Service I cordially dedicate this account of

THE MOST BENEFICENT GOVERNMENTAL WORK OF ALL HISTORY

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INTRODUCTORY

These words are penned just at the time when the citizens of the United States are arising to the stern demands of war. German autocracy is seeking to rule Europe and then the world. After long and patient waiting, submitting to many and altogether inexcusable aggressions and injuries, the United States has joined forces with those who have been the especial objects of the fierce and determined onslaughts of Germany. For the American spirit is essentially opposed to the German spirit. We are as antagonistic as darkness and light. If darkness reigns light disappears. If light conquers darkness is non-existent. Autocracy—Germany—says the few shall rule the many. Kaisers, princes, rulers exist by *the grace of God*. Democracy—the United States—affirms that power inheres only in citizenship, and that there are no "ruling classes" authorized by Divine Goodness. There should be no rulers, claims Democracy; only those who act as representatives of the people's will.

Here, then, the issue is clearly defined. It is freely conceded that the United States has not always lived up to its high ideal of democracy, but not even its bitterest foes can deny that it has been working steadily to the higher planes of democratic thought, life and purpose.

It is to record the most triumphant evidence I believe the United States has yet presented of this onward and upward march that these pages are written. For the work of the Reclamation Service is founded deep in democracy—the needs of the common people, and in the intense desire of thought-leaders, who loved men as brothers, to give the lowliest, poorest, and humblest the opportunities, at least, to reach after the enjoyments of comfort, prosperity and happy living for themselves and their families.

Irrigation has been practised for countless centuries. Within the boundaries of the United States scores of miles of prehistoric irrigation canals have been found, and Egypt, Abyssinia, China, India were all practising irrigation when the writing of history began.

Yet never before in the history of the world have irrigation works of gigantic magnitude been undertaken purely and simply for the benefit and profit of the people. Nay, more, the people ultimately are even to own and control them, as they own and control their wheelbarrows, ploughs, harrows, and automobiles. It is in this regard,—the pure democratization of the great irrigation systems—that the methods of the United States differ from those of all other nations, ancient and modern. The influence of this forward step few realize, even of those who are actually engaged in its triumphant progress, or reaping the benefits of its beneficent march. History, however, will record it as an epoch-forming event, as important to the true development of mankind as the signing of Magna Charta was important to the English people, or the signing of the Declaration of Independence to the American people. It takes democracy beyond the "talking" stage. It is a demonstration. The people are ruling—themselves; the powers of government are being controlled—by themselves; these powers are being used to benefit not a privileged, aristocratic, specially-blessed and endowed class—but the whole of the people. *All who will* may come and partake of its gifts, and millions yet unborn are to see the light of day under conditions as superior to those under which many of our day live that—if they but know—their hearts will overflow with thankfulness and gratitude towards those whose wisdom planned so helpfully for their greater enjoyment of life.

The gift of such a system is a gift not simply to the United States but to the whole world of humanity, and that world owes the gift to John Wesley Powell, the organizer of the U. S. Geological Survey, the Bureau of Ethnology, as well as the father of the Reclamation Service, whose achievements this book recounts. In another chapter I speak more of his work in this regard.

How well I recall the thrills that went over me as, with glowing enthusiasm, this far-visioned lover of his race, this true minister of the gospel of better-living, outlined his plans. Few men knew the arid West as did he. He had travelled over its barren and almost useless acres, miles, leagues, until he knew them by heart. He could locate them in Idaho, Montana, Wyoming, Oregon, California, Nevada, Arizona, New Mexico, Texas, and all the other western states, and his keen eye, too, had taken in—roughly speaking, of course,—the irrigation possibilities of each area. Here, on this river, a storage dam could be located, yonder, its beneficent stream turned into a main canal, which should feed a thousand and one laterals, and thus bring life to the thirsty land.

He visualized before me, so that I also saw them, these dams being erected, these canals excavated, the head-gates and laterals put in, the settlers flocking in, the eager clearing and levelling of the land, the sowing of the seed. He saw and made me see the first rude homes of the incomers going up, he heard the joyous laughter of the children, and saw the hopeful steps of the wives, as well as the eager movements of the men. And as the years progressed he clearly pictured the deserts gone, the waste areas reclaimed, the first primitive homes and barns displaced by the more substantial erections of prosperous farmers, the roads made as solid as those of the Romans, linking progressive towns one with another, where railways would come to connect with the outside world, and all the material evidences of happiness and joy would prevail. He saw schoolhouses, churches, theatres, banks, stores, and civic structures rise in these towns, heard the hum of machinery in factory and mill, and his face shone with a light as of transfiguration, when all these pictures flooded his imagination.

Was it not a great result to labour for, to plan and work, to work and wait, to *urge* and *urge* and *continue urging,* for? This was one of the great motives of Major Powell's life. He was essentially a democratic leader, nay, more, a bishop, a shepherd, a guide to the great flock of men, women, and children, who were never to know him personally, but who were to feel through not only their own lives, but those of their children, for countless generations yet to come, the all-urging love of his great heart.

And to a greater or lesser degree he imbued every one of his lieutenants with the same idea of all-helpful brotherhood. You cannot get men of science to talk of these things; they may even openly and outwardly laugh, or, perchance, scoff at them, yet those whose eyes penetrate the surface, both see and feel that there is a great heart of pulsating brotherhood under the cold or grim exterior of these men. No missionary has ever worked with more devotion to a high and noble cause than have Walcott, Newell, Davis, King, Bien, Lippincott, Hill, Quinton, Whistler, Henny, Savage, Weymouth, Paul, McConnell, Baldwin, Cone, Ensign, Cole, Blanchard and a score of others I might name, for the promotion of the great ends of the Reclamation Service.

As Director of the Geological Survey Major Powell was able to devote considerable attention and time, both personal and of his scientific workers, to the gathering of data to be used in the educational and legislative campaign he had already determined to wage. Few dreamed of the purpose of what he was doing, but by 1887 he had so educated certain leaders in Congress that the Senate itself appointed a committee to make a tour of the arid regions and study their conditions.

Then came the terrible drought of 1890 in the region of the Great Plains. Gardens, farms, orchards withered under the scorching heats, and the waters of springs, creeks, and even rivers seemed to have disappeared. Thousands were ruined and despair ruled in many hearts. Yet it was this very terrible misfortune that put active life into the irrigation movement. Farmers, merchants, newspaper men began to think of the subject, even though they had the vaguest ideas in regard to it. One of them, however, William E. Smythe, then an editorial writer on the *Omaha Bee,* sent out by his chief to study the drought-stricken lands of Nebraska, began to write on the subject. Little by little it expanded, unfolded, until as he himself states it:

> Irrigation seemed the biggest thing in the world. It was not merely a matter of ditches and acres, but a philosophy, a religion, and a program of practical statesmanship rolled into one. There was apparently no such thing as ever getting to the bottom of the subject, for it expanded in all directions and grew in importance with each unfoldment.

The result of these articles was the holding of local conventions in Nebraska upon the subject. These, in turn, led to a State Convention, which was held in Lincoln, where Mr. Smythe was made chairman of a Committee to arrange for a National Irrigation Congress. This was held a few months later at Salt Lake City. Thus the campaign of education was fairly launched. For immediately Mr. Smythe resigned his berth on the *Bee,* launched the *Irrigation Age* and thus became the open and avowed apostle of the new gospel of democracy.

The second Congress was held in Los Angeles, California, in 1893, and how well I remember its sessions. In my *Heroes of California* I have told one of the thrilling incidents that occurred there. Year after year these congresses did their appointed work, and public sentiment was more and more aroused. Senator Carey, of Wyoming, succeeded in getting a bill passed in Congress, granting a million acres of their arid lands to each of the states, provided they would irrigate them. But it was not until 1897 that real light began to shine. The dawn had come, but few were able to read its signs aright until Captain Hiram M. Chittenden, of Yellowstone National Park fame, published his report on *Reservoirs in the Arid Region.* He struck the key-note when he recommended that the government acquire full title and jurisdiction to any reservoir site which it might improve, and full right to the water necessary to fill the reservoir; also that it should build, own, and operate the works, holding the stored waters absolutely free for public use under local regulations.

This report called forth a new propaganda. In the words of Mr. Smythe:

> What was needed at this juncture was an organized propaganda, alive, tireless, sleepless. The Irrigation Congress had done a great work and years of usefulness were yet reserved to it. But it had no funds or paid officers. It met but once a year at widely separated points and always with a different membership. The time had now come when the cause required a working organism quite as effective as that of a church, a political party, or a great business enterprise.

This need was met by George H. Maxwell and his National Irrigation Association, the latter formed at Wichita, Kansas, in 1897, at the close of a meeting of the Trans-Mississippi Congress. Mr. Maxwell was an energetic young lawyer of California, with a remarkable talent for organization and a gift of forceful and eloquent speech. He was one of the numerous converts of the Irrigation Congress, which he joined at the Phœnix convention in the previous year. He determined to abandon his law practice and devote himself exclusively to the irrigation propaganda and the solution of other social problems which, as he clearly foresaw, must go hand-in-hand with the great scheme of reclaiming millions of acres of arid lands. The National Irrigation Association was not to supplant, but to strengthen and supplement, the pioneer institution, the National Irrigation Congress.

Mr. Maxwell saw that nothing could be done without a promotion fund. There must be offices in leading cities, periodicals and newspaper bureaus, and constant activity on the platform. Who should finance the great undertaking? Why not the numerous industrial and transportation interests, who would be the inevitable beneficiaries of new agricultural districts throughout the Western half of the continent and the resulting movement of people and products? Mr. Maxwell believed that if the managers of these enterprises understood their true interests, they would give liberal support to a work of this kind. He proceeded to convince them of the fact, and was thus enabled to carry on the propaganda with a vigour and success unprecedented in the history of the movement. He found an able and indefatigable lieutenant in Mr. C. B. Boothe, a prominent merchant of Los Angeles, California.

The Ninth Irrigation Congress, assembled at Chicago, in 1900, adopted strong resolutions on the line of Chittenden's recommendations. By this time the propaganda had done its educational work so successfully that the politicians began to take notice. All three of the great parties placed planks in their platforms, pledging themselves to the cause of government irrigation. This brought the matter fairly and squarely before the people. In one of the later chapters I shall recount the actual history of the passing of the Reclamation Act in Congress. This book is a recital of the work done in accordance with that Act.

In its preparation I have received aid from numberless sources. A few of these it would be ungrateful of me not to recount in detail. To the kind courtesy and encouragement of F. H. Newell, the first Chief Engineer, and later, Director of the Reclamation Service, and long its animating spirit, for many valuable suggestions, I am most grateful. And in equal measure, and with the same unfailing courtesy, kindness, goodwill and ready response, have I received the generous aid of present Director A. P. Davis, and the Service's Statistician, C. J. Blanchard. Every call for help, for a fact, a figure, a suggestion as to photographs, etc., brought an immediate response, and gave one to feel the joy of the camaraderie of the leaders of this great army of peace. For while I honour and revere the man who uses his genius to prevent the enemies of his country from injuring it, and who places his life in jeopardy to protect the lives of his fellow-citizens and their children, I have an equally deep regard for the man who, without any of the glamour of war, any of its contagious mob-hurrahism, works faithfully, conscientiously, untiringly for the promotion of the higher well-being of his fellow-citizens. "All hail to the heroes of war," I frankly acclaim, when it is a war of protection, of democracy, of defence; but with equal vigour do I shout, "All hail to the heroes of peace."

One of the requirements of the U. S. Reclamation Service of all of its project engineers is a full history of each project, from its early inception, kept up annually as the work progresses. By the courtesy of Mr. A. P. Davis, the Director and Chief Engineer, and the Project Managers and Engineers, I have been favoured with the use of these histories, and in every case have availed myself of their contents.

Practically all of the technical information both as to engineering details, water flow, soil possibilities, etc., pertaining to the projects have been taken *bodily* either from Director Davis's interesting volume, a purely scientific treatise written especially for engineers,[1]—and these Project Histories. As these latter are departmental documents never intended for general publication, I have not hesitated to give the facts required *in the engineer's and manager's own words*, where possible, and I gladly acknowledge this fact.

In the brief fifteen years since the passage of the act of Congress, scores of millions of dollars have been expended, hundreds of thousands of acres reclaimed from the desert, millions of tons of fodder, grain, fruits, vegetables, milk, butter, cheese, and stock produced, hundreds of millions of chickens raised and eggs secured, hundreds, nay thousands, of comfortable homes established, and scores of thousands of men, women and children set walking in the pathways of competency, health, education, and happiness, as the results of its operations.

These great ends were not achieved without the exercise of marvellous foresight, great generalship, scientific knowledge, practical skill, tremendous energy, and persistent effort, yet it has all been done by an army without flaring banners, blaring heralds, the beating of drums, the clashing of cymbals, or the insistent arousement of martial music. As yet the world has not learned to honour its generals, officers and soldiers in the armies of peace, as it does those of the well-advertised armies of war. Most citizens see nothing thrilling in reports on watersheds, reservoir sites, or the discussions of experts as to types of dams, methods of construction, relative values of materials, and the worth of certain cements.

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[1] *Irrigation Works Constructed by the United States Government*, by Arthur Powell Davis, Chief Engineer, U. S. Reclamation Service. John Wiley & Sons, Inc., New York, 1917.

In the following pages I have sought to set forth, in simple and direct phrase, the work of the founders, organizers and present workers of this great Army of Peace—the U. S. Reclamation Service. There are today thousands of families, single men, aye, and single women, in cities, east, west, north, and south, and also in the country places, who long for homes of their own, in the larger, freer West of which they have read or heard. They long for the out-of-door life, greater freedom for their children, larger outlook, greater results from individual endeavour. While the Reclamation Service has issued many small pamphlets descriptive of the different projects which it has brought to successful operation, and others in the processes of development, there in no one work which discusses all the projects from the stand-point of the layman and the homeseeker. This is what I have sought to do.

In so far as I have succeeded I am glad, and if the book gives help to those seeking information and leads them to go out into the large and free spaces of the once arid West, I shall be both satisfied and gratified.

George Wharton James

PASADENA, CALIFORNIA, JULY, 1917.

RECLAIMING THE ARID WEST

RECLAIMING THE ARID WEST

CHAPTER I

THE FATHER OF THE U. S. RECLAMATION SERVICE AND HIS "BOYS"

In Europe today great armies, led by skilful generals, are fighting a war of devastation, destruction, horror, death and hell. Men are being elevated to peerages, dukedoms, receiving crosses and having all kinds of honours conferred upon them because of their skill in destructive acts of war. The human race ever has been hypnotized into hurrahing over the heroes of the battle-field, and those skilled in the arts, crafts, and iniquities that feed the vulture. Personally I have no love for the vulture's croak. I enjoy not the song of the bullet, whether it be British, German, French or Russian; nor for the shriek of shrapnel and the roar of mortar. I see none of the glory of proud-panoplied war. I react to none of its enthusiasms. To me a war of aggression is a relic of barbarism, damning from every standpoint those responsible for it and a proof that they have not yet progressed,—save in exterior polish and material things,—beyond the cave-man and the age of the stone-ax and club. Hence I beat no drum to call attention to eloquent praise of earth's man-made hell. I sing a nobler but, possibly, far less stirring and popular theme. It is thrilling, however.

It was a glorious privilege accorded me, twenty-five or more years ago, of association with Major John Wesley Powell, when he was planning for the salvation of the arid lands of the American West. Here was a conquest that called upon a man's most exalted imagination and taxed his noblest endeavour. With a prophet's superhuman vision and a patriot's true devotion to the highest interests of his fellow-citizens, Major Powell bent the energies of his scientific mind to the organizing of this great warfare. As early as 1878 he made his report on the *Lands of the Arid Region.* No one can read this today, nearly forty years after it was published, without being profoundly impressed by the far-seeing wisdom and sagacity of its author. In it he shows two great advantages of irrigation, viz.: 1. That crops thus cultivated are not subject to the vicissitudes of rainfall, and, 2. The water for irrigation generally comes down from the mountains and plateaus freighted or charged with fertilizing materials gathered from the decaying vegetable matter and soil of the higher regions.

But he also saw that the work was too great to be accomplished by individual enterprise. He grasped its vastness and realized that only under governmental direction and by its expenditures could it be accomplished. He explains many of the gigantic engineering problems involved in extensive storage of waters; the erection of stupendous dams capable of sustaining the never-ceasing pressure of such large volumes of water as would be needed to make irrigation of large areas constant. For he saw that only when the water-supply was assured, by vast storage reservoirs, against two or three successive years of drought, would it be feasible to invite home-seekers to take possession of the arid lands and reclaim them. Ruin and disaster would be sure to follow if water failed for but one year, and, sometimes, for but one critical month. Hence plans must be comprehensive and adequately considered and all the problems involved thoroughly solved.

The conservation of all water supply was also duly considered, and the great broad plan, afterwards so successfully inaugurated under President Roosevelt, was clearly outlined. Though a great friend of the Indian he foresaw that the necessary conservation of snow and rainfall could not occur if the aboriginal population was allowed to continue to roam freely over the public domain, and set fire to the forest for the purpose of driving out the furbearing game and thus securing their pelts. He predicted the need of timber culture, of greater protection of lumbered-over areas, of reforestation.

Then, as a result of his comprehensive study of the conditions existent in the arid lands, he outlined a "Land System," which, however much modified in actual practice, showed a statesman-like grasp of the subject, and, to my mind, the most purely democratic and for-the-common-good system up to that time devised in the known history of the world. He sought to provide against monopolies in both land and water, especially the latter, and insisted that the User-Right of water should inhere to the land upon which it was used. He deprecated the filing upon and holding of large water-rights for speculative purposes, and showed that no person or corporation ought to be allowed to hold water-rights for *future* use against the *actual* needs of *actual* settlers upon the lands. He also counselled the careful and thorough classification of timber, pasture, arid, and mining lands, to prevent fraudulent acquisition of valuable lands under ignorant officials or dishonest claims, and millions of dollars would have been saved to the later purchasers of land, or claimants of government lands, had his safe counsels been more closely followed.

The need for national legislation upon this great subject was early apparent throughout the West. Comparatively few people in the East were able to grasp the situation. Conditions there were so entirely different. There, natural rainfall was relied upon for the natural watering of all crops. Rain fell in abundance. How could Easterners comprehend conditions where annual rainfall amounted to little more than they were familiar with in a month, or, in extreme cases, in even a week? As soon as men began to possess the lands of the arid West and sought to cultivate them the scarcity of water became an irritating problem. Many of the succeeding chapters hint at the distresses experienced during this epoch. But Major Powell, unknown to the sufferers, was preparing for their speedy relief. Slowly, but surely, he was carrying on his campaign of education. United States senators and representatives, public speakers, writers for newspapers, magazines, engineers, chemists, experts on underground water, mountain streams, watersheds, dams, and reservoir sites, were all being moulded for the accomplishment of this work in a manner that now reveals his organizing genius. Years before any one else realized the magnitude of the task, or the tremendous expenditures it entailed, he had foreseen and prepared for the overcoming of the difficulties, and removing of obstacles. With consummate generalship he trained men, with whose abilities his position as head of the United States Geological Survey rendered him familiar, so that they were duly prepared for the position of Director, Chief Engineer, Project Engineers, etc., of the Reclamation Service when it was duly authorized by Act of Congress. He enthused men of eloquent tongues so that they gladly went forth as heralds of the dawn of the new day of irrigation, of reclamation of arid lands. He claimed the serious attention of governors of states, of the financial heads of the nation and of the respective states. He flung forth in clarion tones the new watchword, "Water the arid lands and give them to the people." He bade hope spring up afresh in the hearts of thousands who for years had been "bound to the wheel of labour" in crowded and unhealthy cities.

Opposition sprang up from a variety of sources, some honest, many selfish, all tenacious, pugnacious and pertinacious. United in the one purpose of changing or defeating his plans, Major Powell's opponents sought to discredit his leadership, destroy confidence in his integrity, and defeat his long-matured plans. Openly and secretly, by definite bribe and subtle allurement they sought to divert him from his unselfish, noble, and patriotic purpose. Unflinching, daring, honest to the core, open as the sun-swept deserts he faced his foes and critics, won or silenced them, defied or over-awed them, and yet, at the same time, guided and directed the large army Congress practically had placed under his control. Grant, in the height of his career, never was a more noble and inspiring personage, a fitter subject for the rhetorician's pen or the orator's eloquence, than was this great general of peace, fighting for the happy future of thousands of American citizens, and resolutely following the campaign marked out years before.

In due time the responsibility of generalship was placed in the hands of those who were once his "boys," the lieutenants he personally had trained to carry on his work so nobly and gloriously begun. Before his summons came from the Divine Ruler to "come up higher," he had lived long enough to see the beginning of the consummation of his high hopes, to feel the joyous, thankful throb of many hearts that responded to them, and to see the comfortable homes of happy and contented people spring up where before had reigned the cactus, the rattlesnake, and wild desolation.

Of course mistakes were made, many and various. Wherein has any great work been accomplished without mistakes? Here, however, a new departure was being taken. A work on a larger scale than the United States had yet attempted was to be begun. There was scarcely an engineer in the land whose experience was to be compared with the features which now loomed up largely in the horizon. Private and corporate—even state—capital had shrunk back appalled at the gigantic tasks that the Reclamation Service was now about to attempt.

There were a few leaders, who were so far competent, but every man had to be tested, proved, anallysed, in the searching light of his own endeavours, grappling with gigantic problems that had never been solved elsewhere, feeling his way; experimenting if you will—the only thing possible, unless each engineer on his own problems had been given superhuman perspicacity, intuition and foresight.

What man of brains is there who would expect, under such circumstances, anything less than that errors would be made, false steps taken, wrong conclusions arrived at?

It was in the nature of things, that, no matter how high the motives and aims of the earlier promoters of this work, they should have failed to grasp all the problems that confronted them. The very exuberance of their high hopes led them to see over—"overlook"—some of the difficulties that were sure to arise, as well as the slothfulness, sordidness, meanness, laziness, of some who would want to take advantage of the great possibilities the Government offered.

But in the light of the great achievements of the Service the mistakes are insignificant and unimportant, and none but a small-minded carper and caviller would refer to them in any other spirit.

What should be recalled is the work accomplished, while fights were going on in the halls of legislation to defeat the purely democratic character of the work as outlined. Exploiters, who sought their own selfish ends, endeavoured to control legislation, so that the national government would be induced to expend its money on the gigantic engineering features of vast irrigation systems, and then allow the watered lands to be controlled by the states in which they were located. Graft and corruption spread their hideous heads on every hand, and bribes were offered and alas! sometimes taken, though the band of federal leaders stood firm for the principles they had enunciated.

And so the work progressed, and great structures began to rise throughout the West, though in such remote and inaccessible locations that the ordinary citizen knew nothing of them. When ultimately he was aroused sufficiently to visit them he exclaimed in astonishment at what had been achieved.

How little the outside public dreams of the precautions taken by the engineers to see that all the great features of these gigantic structures were proof against any contingencies that might arise. Days, weeks, months, even years of careful and thorough observations, afterwards judicially analysed and collated; conferences, discussions, investigations on the ground by chief engineers, consulting engineers, project engineers, assistants, and local men who might be supposed to know of peculiar or occasional conditions not generally understood; watching the progress step after step, checking up, testing, gauging where possible—the anxious care, the devotion accorded to every department of this work, few know or realize.

Struggling with the torrential flood-waters of the California and Arizona streams, where river-banks wash away in a single night; listening to the pounding and grinding, smashing and crashing of ice piling up in streams, and waiting breathlessly for the breaking of the jam and watching the fierce waters hurling the stupendous masses of ice with terrific velocity upon the dams in the frozen streams of Montana and Idaho; battling with millions of gallons of inpouring water; puzzling over chemical problems such as the eating away of solid concrete by elements in the water which were not understood; seeing a whole community waiting for water when it was most needed, because improperly constructed private canals broke and filled up the government's canals with silt and debris, or washed them away, so that water could not be delivered; watching the flow of a great stream sink away in a reservoir which had been created at great cost, as at Hondo; these and a thousand and one disheartening experiences had to be met and overcome.

I do not write of what I imagine; I tell that which I know, for I have been present at these discussions; I have heard the frank criticisms, the open objections, the fearless questionings. One aim, and one only, seemed to animate every man in the work, and that was to give the best service that was possible to him. Success in the highest, fullest, broadest sense, was the only goal worth striving for, and to gain this, every ounce of a man's physical strength, every reaction of his mental power, every truest faculty of his soul, must be alert, intent, devoted to his task.

Another important feature should be named here. Not only were precautions taken against accidents to the engineering features, the dams, reservoirs, head-gates, canals, and general distribution system of the water, but, during the progress of the work of construction far greater care was exercised to make everything healthful and sanitary for the workmen employed and also for the future.

Imagine the sites of these great works, during the construction periods, practically all of them far away from towns or lesser settlements. Each one was the sudden dumping-ground of a small army, from directing engineers to rudest labourers. Their food, water, sleeping accommodations, and every day needs, such as bathing, laundry, hospital, club-house, general recreations, etc., had to be provided for, The following extract from a report of one of the engineers is typical of what was done everywhere:

> At once, the problem of sanitary protection became of vital importance. It was comparatively simple to care for the main camp, which was under the absolute control of the Reclamation Service, but when little settlements began to spring up here and there, as more and more of the men brought their families to the job, the problem became more complex. Fortunately, public sentiment was all in favour of enforcing the necessary regulations. These covered the location, proper construction and disinfection of toilets, disposal of garbage, protection of water-supply and the fighting of flies. The camp physician was given the duties of chief sanitary officer, and under his direction the camp foreman and his crew of janitors and camp men looked after the main camp. To aid in the proper enforcement of the necessary regulations outside of the main camp, it was arranged to look after the necessary work like disinfection, garbage collection, the furnishing of garbage-cans, fly-traps, etc., at a certain fixed charge for the service performed, and nearly all of the persons living outside of the main camp were glad to take advantage of this arrangement.
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> All applicants for employment were given a brief physi-

cal examination by the resident physician, which was made more thorough if deemed advisable. In this way the unfit or undesirable were eliminated. Vaccination for smallpox or anti-typhoid inoculation was given at the hospital without charge.

Air-tight metal garbage-cans were provided, and were kept in serviceable condition. Garbage and refuse were collected every day or two, hauled away and burned. No breeding-places for flies were allowed to exist. Fly-traps were used constantly. All toilets and buildings where flies would be attracted were screened and provided with special screened entrances. Sleeping quarters were scrubbed, aired and disinfected frequently. Iron springs and mattresses were provided, and these were taken out and cleaned periodically. The cost of this work was not high, but the results were most satisfactory, as the general health of the community has always been away above average; there have been no epidemics of any kind and only one case of typhoid, which probably originated outside of camp.

This helpful, humanitarian spirit has been paramount from the inception to the completion of the work, so far, and I am sure will continue to the end. I speak in sincere earnestness when I affirm that I know of no body of men, in public work, so single-eyed, so devoted, so absolutely absorbed in their work, as I have found the engineers of the United States Reclamation Service to be. These are the men I would crown with laurel, the public servants I would serenade (if such a procedure is ever desirable), the leaders I would decorate with honours and titles. The debt of gratitude the Nation owes to them can never be estimated, never adequately appreciated, never repaid.

And yet, in a speech made at Stanford University, California, March 24, 1911, ex-president Roosevelt gave full notice to the men engaged in the great work of the Reclamation Service as to what they might expect from both government and people. He had learned that republics proverbially are ungrateful, and said: "There will be no exceptional reward for these men. Those who are sufficiently prominent will ultimately be investigated by Congress. That you will have to expect."

In spite, however, of this doleful prognostication by one whose experience and practical knowledge of congresses none can question, this Army of Peace holds steadily not only to its work, but to the high democratic ideals that originated it.

CHAPTER II

THE ORIGIN OF THE RECLAMATION ACT

In other chapters a brief recital is made of individual work leading to the passage of the Reclamation Act by Congress. To give full attention to the claims of all who aided in its passage is impossible, even were it necessary. It seems to me important, however, that some idea of the gigantic task the passage of such a measure entails upon many, should be given to the general reader. I have already shown how Major Powell began the campaign of education, laying the foundations of the work to be in the fundamental principles of human brotherhood. Also how he trained some of the later leaders and workers while they were his subordinates in the United States Geological Survey. The helpful lay work of William E. Smythe and George H. Maxwell, in the campaign of education, was of inestimable value, but actual results of legislation were a prime essential, when the time was ripe. This was accomplished as follows.

The Senate and House of Representatives were both familiar with irrigation bills, but they were all local and framed solely for the benefit of specific districts. There was no united, broad, comprehensive spirit of real development in the vision of those who fathered them. The members of the East and South knew nothing and cared less about irrigation. It was a subject as foreign to their conceptions of the needs of the United States as though it had applied to Kamschatka or Beloochistan. Even President McKinley, after his re-election, made no reference to it in his message. But the subject was discussed with considerable enthusiasm, notably at the ninth annual session of the National Irrigation Congress at Chicago, Ill., November 21 to 24, 1900. At this meeting Mr. Francis G. Newlands, then Representative from Nevada, and Mr. George H. Maxwell, chairman of the executive committee of the National Irrigation Association, were particularly energetic in the discussion of proposed legislation. At that time there were two radically opposing views struggling for recognition. The first was for national development and the second was for turning over the public lands or their proceeds to the States. Messrs. Newlands and Maxwell were particularly enthusiastic in their advocacy of the first course.

At this time Frederick H. Newell was doing important work in the Geological Survey along national irrigation lines, in accordance with the Powell policy and plans. He was the best man, therefore, in the United States, to give definite and practical shape to any contemplated legislation, and on November 30, 1900, Mr. Newlands called upon him to discuss a bill which he proposed to introduce into the House, in which he was then a representative from Nevada. At his request Mr. Newell prepared a draft of a bill, which he introduced on December 17, relating particularly to water storage on the Humboldt River in Nevada.

Let Dr. Newell now tell the story in his own words, as given in his testimony, February 5, 1909, before the Committee on Irrigation of Arid Lands, House of Representatives.

> At that time he [Mr. Newlands] was convinced that there should be a more general bill, and I assisted him in drafting a measure along the lines of the River and Harbour bill. He continued his agitation of the subject in and out of Congress and had a series of evening meetings at his residence, where, on January 8, 1901, I had the pleasure of delivering an illustrated talk, showing lantern slides similar to those which I have shown before this committee. There were present at that time the Secretary of the Interior and many of the western Members of Congress; in all about sixteen public men.
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> Growing out of this activity both committees of the House, namely, that on Public Lands and that on Arid Lands, began to hold meetings. The hearings before the Committee on Public Lands were held on January 11, 18, 23 and 30, and were addressed by Mr. Newlands, Mr. Maxwell, myself, and others. The bill presented by Mr. Newlands was H. R. 12844, and served as a text for his discussion. The Committee on Irrigation of Arid Lands held hearings from January 28 to February 9.
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> During the progress of these hearings Mr. Newlands kept up his activity, and on January 17 gave a dinner to the Public Lands Committee at which the outlines of the bill were discussed in general terms, and on January 22 he asked me to assist in drawing another bill. On January 25 my records show that we discussed the bill, setting aside the proceeds of sale of lands for purposes of irrigation, and with Mr. Maxwell's advice it was put in definite form. The next day after some further consideration of the provisions with Mr. Maxwell and myself, Mr. Newlands introduced the bill, H. R. 13846 (56th Cong., 2d Sess.), setting aside moneys received from the sale and disposal of public lands.
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> This bill (H. R. 13846) attracted at once considerable attention and formed the basis for a number of similar bills introduced by other members. It contained the principal

elements of the Reclamation Act as finally passed. The first section set aside the money derived from the proceeds of public lands and authorized construction, and the second section authorized the Secretary of the Interior, through the Director of the Geological Survey, to continue the examination and ascertain the practicability of diverting rivers and of providing supplies of water by artesian wells. The third section provided that reports should be made, and the fourth section covered the question of withdrawal of lands. Provision was made that "the right to the use of water shall be perpetually appurtenant to the land irrigated and beneficial use shall be the basis, the measure, and the limit of the right," this being the language which Mr. Maxwell had worked out at various sessions of the Irrigation Congress. Provision was also made for irrigating private lands and for making payment in ten annual instalments, limiting the entry to 80 acres.

The next question discussed by Mr. Newlands and his friends was that of getting the bill advantageously introduced in the Senate, as it had been proposed in the House by a member of the party in opposition. After considerable discussion at Mr. Newlands' residence, and acting on the advice of Senator Pettigrew and others, it was concluded to ask Senator Hansbrough to introduce the bill. Mr. Maxwell was asked to approach him on the subject. As a result, on January 31, Senator Hansbrough introduced the bill as S. 5833. (He refused at first and was persuaded with difficulty.) This was reported from the Senate Committee on Public Lands on February 4, 1901, with a few amendments, which were subsequently rejected.

In the meantime, Mr. Newlands was actively at work discussing his original bill (13846) and perfecting it in detail. He introduced it again and again under different numbers. It appears as H. R. 14088, of February 6; H. R. 14326, of March 1; and still again as H. R. 14338, the changes in each case leading toward the form ultimately adopted. The hearings of the House Committee resulted finally in report from the Committee on Public Lands, being known as Report No. 2954, and presenting a bill known as H. R.

14280, embodying the idea of a reclamation fund and authorizing the Secretary of the Interior to make surveys and examinations and to construct the work. It is essentially a brief summary of the first part of the Newlands bills.

. . . The closing days of the Fifty-sixth Congress were marked by great activity in the introduction of similar bills and discussion of them. The attention of the entire country was drawn to the subject by the sentiment broadly disseminated that one of the reasons for Senator Carter's "talking to death" the River and Harbour bill was found in the fact that the West could not secure recognition of its needs. With the close of this Congress there seemed to be a clearly outlined policy, looking toward the early enactment of legislation along the lines indicated above, and which would carry out the pledges made by the different political parties.

The matter was not allowed to rest, but was discussed at the various conventions. Efforts were revived to sidetrack the idea of national reclamation by turning the proceeds from the disposal of public lands over to state officials. Enough was done in this direction to stimulate the friends of national irrigation to still greater efforts.

Immediately following the death of President McKinley, on September 14, 1901, Mr. Roosevelt gave personal attention to the subject, and on the next but one Sunday following I was instructed to meet him, and on the afternoon of September 23, at the house of his sister, Mrs. Cowles, he discussed fully the whole situation, asking Mr. Gifford Pinchot and myself to prepare memoranda which he might use in his first message to Congress on the subject of forestry and irrigation. This message called the attention of the Fifty-seventh Congress to the matter. It was already in the minds of the western members, but they seemed hopelessly divided on the subject.

It was recognized that if success was to be attained there must be unity of action. Accordingly a general meeting of western members was held on December 3, 1901, and an organization perfected by the selection of Senator Francis E. Warren, of Wyoming, as chairman.

This committee held almost daily sessions, and Mr. Newlands, as secretary, submitted a report on December 28, 1901, with a draft of a bill which embodied the ideas of the original Newlands bill and the legislation favourably reported by the Senate Committee on Public Lands and Arid Lands.

Final action on the subject was set for January 7, 1902. From this time forward the progress of the Reclamation Act was confined mainly to matters of detail in securing the attention of Members, organizing forces, and arousing public opinion. In the latter Mr. Maxwell was particularly active. The history of the passage of the bill is in the debates in the *Congressional Record.* It finally passed the House on June 13, and became a law upon the signature of the President on June 17, 1902. It is interesting and instructive to read the various successive drafts and note the changes in language, denoting the great care with which every word and line has been scrutinized.

A study of the changes is valuable in explaining why the Reclamation Act has been so successful. Many of the men who are not conversant with the great care with which the bill was prepared have expressed surprise that so few changes are considered necessary even after six years of practical experience. It must be borne in mind, however, that the bill was drafted and revised not wholly as an experimental measure, but as one resulting from many years' investigation of the subject by men who had made it a life-work to thoroughly know the physical conditions of the West and the results accomplished by private and corporate enterprise. The bill, in other words, is not one which has been prepared on a theoretical basis by men who have simply been students of economics, but before its passage was subject to the most rigid scrutiny by thoroughly practical irrigation men and lawyers versed in water litigation.

President Roosevelt's interest in behalf of the bill cannot be over-estimated and he deserves all the honour that attaches to his name at the Roosevelt

Dam and elsewhere for his earnest advocacy of the cause. Unlike his predecessors in the presidential chair he was familiar with the arid West and its needs. As a young man in delicate health he had come out to a ranch in Wyoming, and had there fellowshiped with cowboys, hunters and men who knew the country and its possibilities. He there saw with his own eyes the marvels of irrigation on soil that was called desert, and this and a hundred other experiences impossible in the East, gave him not only a knowledge of the West, but an intuitive sympathy with it that could have been gained in no other way. In his first message he put the question upon a national basis. He said:

> The reclamation of the unsettled arid public lands presents a different problem. Here it is not enough to regulate the flow of streams. The object of the Government is to dispose of the land to settlers who will build homes upon it. To accomplish this object water must be brought within their reach.
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> The pioneer settlers on the arid public domain chose their homes along streams from which they could themselves divert the water to reclaim their holdings. Such opportunities are practically gone. There remain, however, vast areas of public land which can be made available for homestead settlement, but only by reservoirs and main-line canals impracticable for private enterprise. These irrigation works should be built by the National Government. The lands reclaimed by them should be reserved by the Government for actual settlers, and the cost of construction should, so far as possible, be repaid by the land reclaimed. The distribution of the water, the division of the streams among irrigators, should be left to the settlers themselves, in conformity with state laws and without interference with those laws or with vested rights.

Then, in speaking specifically of irrigation of the arid West in detail, he followed closely the lines laid down in the Newlands bill.

To show, however, how its enemies sought to emasculate the true democracy of the bill, it is well to refer to the fact that in joint committee the feature of Mr. Newlands' bill providing for the withdrawal of lands from entry under all laws except the homestead, without the benefit of the commutation clause, until the works should be finished and the water actually ready for delivery, was stricken out by the committee.

As William E. Smythe effectively states it:

> This action was intensely disappointing to the organized irrigation movement, who believed it was done solely in the interest of land-grabbers who desired to get possession of the choicest morsels of the public domain in advance of homeseekers. George H. Maxwell declared that it amounted to a betrayal of the most sacred objects of the movement and said it was infinitely preferable that the entire measure should be lost at that time rather than that a condition should be created under which it would be not only possible, but probable, that the lands would be stolen before the genuine homemaker could get an opportunity to file upon them. His aggressive stand aroused a storm of opposition to the amendment. It resulted in an animated conference at the White House, at which the President announced that he would not sign the bill in that shape. The original provision was then restored so that it was made impossible for any one to obtain title to public lands irrigated by the Government, without five years' residence and actual cultivation.

Thus restored to its original condition the bill passed the House, June 3, 1902, by a vote of 146 to 55. President Roosevelt signed it on June 17, the 127th anniversary of the battle of Bunker Hill.

CHAPTER III

IRRIGATED LAND FOR THE LANDLESS

For centuries, in every so-called civilized country, the land has been the property of the few. The masses of the people were allowed to live upon it, to work it, to make it productive, but the ownership and whatever profit accrued from its cultivation belonged to the few who claimed its possession.

True democracy has sought to change this condition. A practical belief in the brotherhood of man compels the endeavour to put our brothers upon as good a footing as we ourselves stand. But human selfishness dies hard. It thinks first not only of itself, and its actual needs, but its refinements, luxuries and even dissipations, and looks on, as none of its affair, at the pathetic and oftentimes vain struggles of others less able, less fortunate, or less rude than themselves in the strenuous battle of life.

While the new day has "dawned," it has not yet come to its full high noon. The day of large land-ownerships is not yet passed, I regret to say; but it has begun to pass. A break has been made. The vast land-holdings in America are being divided, and the different countries of Europe, even, are awakening to the fact that the monstrous injustice of the so-called higher class, in holding their vast estates without adequate taxation, and sometimes with no taxation at all, can no longer be tolerated. The day is coming foreshadowed in Edwin Markham's "Man with the Hoe," when the brutal creature, bowed down by the weight of centuries, shall begin to rise in dumb rebellion. His eye is catching the flash of God's own light of freedom and *real* manhood. He is beginning to stand upright; to see the "swing of Pleiades," and to feel the beginnings of desires and aspirations to which he has hitherto been a stranger. He sees these wide lands in another light than did his forefathers. Why should he not own a small fraction of them? or at least be enabled to cultivate them and reap the produce for himself and his family, rather than for others?

Little by little these dreams and newly sprung aspirations have grown. Slowly men have seen and realized their inherent birthright. Now they are crying in loud chorus; "It is for us to possess what the Creator evidently intended should be ours at least for use and blessing."

The Homestead Laws of the United States were this country's answer to this essentially natural human cry. Thousands of pioneers settled upon the public lands, struggled up from poverty to affluence as the result of their own endeavours upon the soil of a free republic, and thus demonstrated to the world the inherent power of a true though not fully developed democracy.

Our homestead laws, however, were abused, as were the desert, forestry, and mining land acts. Capitalists, by fraud and collusion, secured large tracts of land, contrary to the spirit of democracy, and held them for speculation. At first, neither the officials of government nor the people seemed to care, but after a few generations had passed it was discovered that the public lands were shrinking with fearful rapidity. All the choice pieces were already absorbed from the public domain. Nothing but the undesirable portions remained, or the barren and desolate desert areas of the West that were regarded as practically useless.

This cry led to a tightening of the laws. But the locking of the doors of the land stables did not bring back the stolen horses. They were gone, and gone forever.

Hence, when the fathers of irrigation began their campaign, they decided to safeguard as far as possible the irrigated arid lands from the thief, the monopolist, the grabber, and keep them to become the actual homesteads of those who would live upon, improve, and actually enjoy them.

How well they accomplished their aim history is rapidly recording, in the joyous testimony of thousands and thousands of families who are *landowners* —and in spite of the hardships they think they have had to endure, are a thousandfold better off than their fellows in autocratically governed lands.

Yet few there are who can see that these joyous results have come about through the *aridity* of the western lands; that had these public lands been naturally watered, as those are in the East, this further triumph of democracy would not have taken place, perhaps, until weary and bloody centuries had elapsed.

It is this very feature that it is so important to discuss.

There are certain public works that are too large, too stupendous, to be undertaken by any but the government. Such was the building of the dikes that protect Holland from the sea; the great road-systems of the Romans; the building of the Panama Canal; and the leveeing of the Mississippi River. The work of the Reclamation Service is of this same gigantic character. The cost of a single dam in several instances has gone into the millions of dollars, and except as a government measure the carrying on of these works would have been impossible. Had the lands been well watered as those east of the ninety-seventh meridian the West would have been settled up under the same conditions as those that obtained east of this line. But individual settlers—after the first few had located upon the sides of running streams—could not cope with the dry conditions. Even when a band of them "got together" and tried to put in their diversion dams and canals the floods and freshets, in every known case, sooner or later washed them out, and their last estate was worse than their first. For, in many instances, the settlers had cleared desert lands with incredible labour, levelled them, put in their crops or orchard, *relying upon a constant supply of water.*

So long as water flowed they were happy, and things looked promising, but when, through the washing out of a dam, the water stopped, then actual Ruin arose and grasped them by the throat. It was no slow process. In the hot sunshine of the West one week without water on their crops meant dire disaster, and a full month, irrevocable ruin.

The farm-home-seeking instinct of the American people urged them out upon the public lands, but when all those east of the ninety-seventh meridian were taken up the cry began to arise: "Give us the West." To the uninformed Easterner the cry was absurd. The West was a desert. We have but to read the expressions of some of our wisest statesmen in the houses of Congress to know how useless the major portion of the lands of the "great western deserts" were regarded. Contempt for their possibilities was the least expression of the popular eastern disregard. Hence the need for the campaign of education, so effectively organized and carried on by Powell, Smythe, Maxwell, and by Newlands in the House and Senate. To the millions of the East the West was "the land that God forgot." In the light of the experiences of today how fatuous was this blindness. Yet how true it is that what man today, in his ignorance, regards as a curse may tomorrow turn out to be his greatest blessing. The scientist now tells us,—and the cultivation of millions of acres in the arid West has proved its truth—that the very condition of aridity is an assurance of great fertility when water is applied. Professor E. W. Hilgard of the University of California, the greatest agricultural expert the West has produced, thus stated the case:

> Soils are formed from rocks by the physical and chemical agencies commonly comprehended in the term weathering, which includes both their pulverization and chemical decomposition by atmospheric action. Both actions, but more especially the chemical one, continue in the soil itself; the last named in an accelerated measure, so as to give rise to the farmer's practice of "fallowing"—that is, leaving the land exposed to the action of the air in a well-tilled but unplanted condition, with a view to increasing the succeeding year's crops by the additional amount of plant-

food rendered available, during the fallow, from the soil itself.

This weathering process is accompanied by the formation of new compounds out of the minerals originally composing the rock. Some of these, such as zeolites and clay, are insoluble in water, and therefore remain in the soil, forming a reserve of plant-food that may be drawn upon gradually by plants; while another portion, containing especially the compounds of the alkalies—potash and soda—are easily soluble in water. Where the rainfall is abundant these soluble substances are currently carried into the country drainage, and through the rivers into the ocean. Among these are potash, lime, magnesia, sulphuric and a trifle of phosphoric acids. Where, on the contrary, the rainfall is insufficient to carry the soluble compounds formed in the weathering of the soil-mass into the country drainage, those compounds must of necessity remain and accumulate in the soil.

Is it not singular, in view of Professor Hilgard's contention, that careful readers and observers had never noted that the most fertile countries were the arid ones, and not the humid and well-watered ones? In spite of crude implements and obsolete methods India, China, Egypt, Palestine and other arid or semi-arid lands are the most famous for their fertility. Various explanations for this fact have been offered, as, for instance, the commonly referred to overflowing of the Nile, thus depositing its fertilizing sediment upon the land. This idea held, and still holds, so firmly that many believe it is the sole explanation, and yet in the Colorado River country, the irrigation-farmers are spending many thousands of dollars in eliminating this river-sediment before the water reaches their lands.

There are other conditions, however, than the fertility of the soil that render arid countries desirable to live in. It is no mere figure of speech to refer to them as "lands of blue sky, sunshine, pure air and cool nights." The arid West is the nation's God-given sanitarium. How many hundreds of thousands have found it so. There is no muggy, overpowering, sweltering heat, day or night; fierce, biting heat, there certainly is, but it is dry and therefore not conducive to sunstroke or apoplexy, or the lesser discomfort of perpetual stickiness.

This absence of humidity renders both heat and cold far more bearable and therefore arid countries are more desirable as places of residence, winter *and summer*, especially for the old and feeble, the frail or diseased, than those that are humid.

To go back now, however, to the cry of the home-seeker for these arid western lands. To be lived upon they must be made fertile by the application of water. This could be done only by the co-operation of a number of settlers, or by the intervention of the government, and in either case the demand arose for co-operative effort and co-operative purpose. Alone, a man, however able and industrious, starved. He could not turn the course of a river, build a canal system, conduct water across great ravines or yawning chasms, or construct immense storage-dams. Co-operation, therefore, was imperative. The value of the learning of this lesson, prior to the Government's taking upon itself the burden of reclamation, few can estimate. It is the chief secret for the difference that every sentient person from the East feels immediately he strikes the West. There is a new "feeling" in the very atmosphere. The land is different, the scenery is different, the people and their habits are different.

The co-operative efforts of the men of the West also taught them many other important lessons, which are to influence mankind's progress to the end of time. For instance, they began to realize that the final test of "right" to water was that *it be put to beneficial use.* The old English law of riparian rights, viz., that one was *entitled* to a proportionate share of all water flowing by his land in accordance with his land-holdings, long since was found to be inadequate to cope with the water problems of the West. The present laws, therefore, in many of the states, practically declare it to be obsolete, and the usage established by the Reclamation Service is now obtaining on every hand, viz., that the *only right* one *can* have to water that is needed for the general good, is the right *beneficially* to *use* it. This principle is also applied, in some, perhaps all, of the western states to springs, etc., originating upon lands that are privately owned. No longer can a selfish proprietor say: "I own this water, and whether I care to use it or not is no one's business. It is mine, and here it stays until I want it." The State steps in, and gives to any person who will beneficially use it, the right to appropriate and pipe it away. And an actual right of use thus gained is an appurtenant to the land, not to be bartered, or sold away from that land but kept for beneficial use there and there only.

In order to aid in a clear understanding as to the meaning to be attached to the term "beneficial," there have been many conferences upon the matter by those interested. It has been shown clearly that the most beneficial methods are those that produce the *best results* from the most *economical* use. As there is water enough, so far flowing, developed, or stored, to meet the demands of a relatively small percentage of potentially irrigable lands in the West, it necessarily follows that the economical use of water is a question of as great importance to the public welfare as is the beneficial use to the welfare of the individual. Therefore, every true patriot, every good and unselfish citizen, will endeavour to instruct himself that he can the more economically use the water that a beneficent government has aided him in securing for his personal benefit.

In speaking of riparian rights there is another requirement the western irrigation usage has done away with, viz., that all users of water from a river must return it to the channel undiminished in quantity. This, of course, is directly antagonistic to irrigation, as a large amount is absorbed both in the soil and the growing things. Hence all irrigation states have modified or rejected the riparian doctrine.

When the Reclamation Act was being considered these essential and basic principles—contrary to the universal usage of the world—forced themselves to the forefront. The "practical politicians" laughed when they heard such expressions as "There shall be no monopoly in government-irrigated land." Yet who is there—except the monopolist himself—that does not realize the immense wrong done to the real homeseeker, the toiler, the would-be farmer who loves the land he desires to see productive under his hands with an intensity he cannot suppress, by those who "own" land for speculative purposes? I believe with John Ruskin that the time will come when such a monopoly will be regarded by decent men as *worse* than highway robbery. Major Powell, Senator Newlands and others saw that all our laws needed reform in this matter, but they determined, if possible, to so construct the Reclamation Act that it would not need to be reformed. It should contain within itself the leaven that would ultimately change all laws that made monopolies of the things of God in Nature possible.

They planned, therefore, so that the Reclamation Act forbade the delivery of water on any government project to privately owned lands to a greater extent than 160 acres. Thus an effort was made to take it out of the power of capitalists and speculators in land to take selfish advantage of the beneficent work of a government of democracy designed for the benefit of all citizens alike who desired to avail themselves of it. Pressure was thus brought on the owners of large tracts to divide them, to sell to those who would develop them, and thus the army of our small and prosperous farmers is rapidly growing.

Even sovereign States have been so carried away with the spirit of landlordism that they have sought to hold on to land irrigated by the Reclamation Service for speculative rises in price. In every case this spirit has been checked by the Service. For instance, the State of Washington owned certain lands in the Tieton unit of the Yakima Project. Secretary Lane wrote to Governor Lister, calling his attention to the fact that "development is arrested by certain State lands withheld from cultivation, it is alleged, in a spirit of speculation, the State holding for future profit."

The governor responded that he would bring the matter before the State Land Commission, and the lands in question have since been appraised and offered for sale.

The farm unit upon the Reclamation Projects was fixed at forty, sixty, eighty acres—seldom more—and private owners of land were prohibited from purchasing a water right for more than 160 acres in one ownership.

Then the act affirmed the people's ownership of water, to be beneficially used after it had been conserved and stored. But in its distribution for beneficial use each man, no matter how much or how little land he owned, should be on an equality with every other man. Here was a new note in pure democracy. It struck at water monopoly, and practically made the water-right belong to the land, from which nothing could ever alienate it.

The storage and diversion dams were to be built, canals and laterals constructed, and water actually put upon every man's land by the government. The costs were to be paid back in ten yearly payments, without interest, and, when these payments, with the annual maintenance and operation costs, were completed, the whole works were to be turned over to the people who owned the irrigated lands.

Again the politicians laughed. This was a joke; it was revolutionary; it was unconstitutional. They did not regard it as worth serious consideration. It so far violated the old-time political methods that they could not see the handwriting on the wall.

Even the leaders were so blinded—fortunately—that they were assured the bill could not pass, so that they made no attempt to muster their forces to defeat it. And none were more astonished than they to find themselves swept to defeat by the response of the great body of the House of Representatives to the popular demand.

It was the tolling of the bell of doom to selfish, monopolistic, special-class legislation. They did not see it. Few did, but, nevertheless, it is perfectly clear, and future centuries will note this as the epoch-forming time.

The act was passed. The president had signed it. It had become the law of the land. Charles D. Walcott was appointed the first Director, and F. H. Newell the Chief Engineer. The organization of the workers began, and the politicians now took it upon themselves to dictate as to who should be employed, what projects should be started, where dams should be located, or, in other words how they should finger as much of the money of the Service as they could. Needless to add a fight was on at once. Steadily, but firmly, they were bidden to keep their hands off, and this policy has ever since been adhered to.

While this struggle was being precipitated in Washington, another of a different character, was being forced upon the engineers in the field.

Not even the most sanguine of the workers for the establishment of the Service dreamed of the impatience of the people to get upon the land as soon as the bill was passed. Demands for the starting of the work poured in from home-hungry people all over the West, and many impatient ones, refusing to listen to the wise counsels of the leaders, rushed upon the land, paid their preliminary fees, started to clear and level their holdings, built their rude homes, and then were compelled to sit idle because water could not be supplied to them for one, two, three, or more years to come.

One result of this uncontrollable impatience was that the officials, naturally desirous of making every reasonable effort to meet popular need, began with very limited data in regard to the probable extent of work required and future conditions of crops and markets. This led, naturally, to underestimates of final costs, and when the people began to realize that these costs were larger than they anticipated and must ultimately be paid, considerable dissatisfaction was expressed.

Yet in spite of difficulties of every kind the work went quietly on. And it is a joy to relate that more favourable developments arose than obstacles. One of these was the realization of the wonderful possibilities for the development of electricity on the various projects. Millions of dollars will ultimately be saved to the farmers in this one item alone, and in the chapters on the Salt River, Minidoka and many other projects it will be seen what the utilization of this power already signifies to the farmers.

It was soon found, also, that telephones were necessary for the actual needs of the engineers, and, as canal-systems developed, to give timely warning of floods, breakages, etc. In due time these telephone systems were made available to the settlers, and when the projects are paid for, in most cases they will be owned and operated by them.

So the good work goes on.

How wonderfully, sometimes, things with which we are perfectly familiar strike us with new force under new conditions. For a life-time I have sung the majestic chorus of Mendelssohn, from *Elijah*, "Thanks be to God; He laveth the thirsty land." Again and again have I thrilled to its passionate power, but never did I dream of its full significance until I saw water pouring through the irrigation canals of our thirsty West; the gentle murmuring of the flowing waters suggesting the music made by the land as it sucked up, absorbed, drew into every thirsty pore, the life-giving, stimulating, seed-growing fluid.

CHAPTER IV

SOME OF THE DIFFICULTIES

Many of the difficulties encountered in the earlier days of the agitation for irrigation of the arid West, in the passage of the Reclamation Act, in the building up of the organization of engineers, etc., have already been recounted. There are others, however, a few of which it seems well to present to my readers that they the more fully understand the greatness of the results already accomplished.

Not the least of the difficulties the Service had to contend with was where public men attempted to use their positions to obtain information of projects under consideration, so that they might pose before the public as directing, influencing, or advising the Service to their political advantage. Again and again, both at the head offices in Washington, and the local offices throughout the country, "prominent men" would appear, and indignantly criticize the engineers and others for their "unnecessary secrecy," refusal to give out facts and figures, neglect to avail themselves of the information possessed by local authorities, etc., etc.

Yet it can readily be seen, *now*, that in spite of the caution and care of the Service, the most casual remarks were seized upon and made the basis for later criticisms. Take the Klamath project as an illustration. Because of the very listening to the "local authorities," and taking the "public men of the region into their confidence," the tentative remarks of the engineers were resolved into pledges of original cost of construction. The newspapers and others boomed these purely casual remarks, based generally upon the consideration of the "facts and figures" of the "local experts."

One of the greatest difficulties was often caused by the settlers themselves, in their haste to get upon the land. They saw the water that was to change their uncultivated lands running to waste. It appeared to them a tremendous quantity—sufficient to irrigate ten times more land than they had located upon. But water supplies are inconstant; they vary within a wide range. One year there may be a heavy rain-fall, and the next a larger still, only, however, to be followed by three or four seasons of drought. Think, then, of the terrible predicament of men, with their families, and their stock, located upon lands which they have reclaimed from the original desert, levelled, ditched, and planted out to orchard or crops—all in good faith and in supreme reliance upon the ability of the "government" to supply all the water all of them might need, whenever they needed it. Now they are confronted by a serious and perilous situation. Nature and the government have failed them. They have little or no water at the very time they must have it, or their crops will dry up, their young trees will die, they themselves will be ruined.

Exactly this situation has occurred both before and after the Service entered the field. Impatience and want of foresight, going hand in hand, often produce serious consequences. Many a man has toiled, slaved and expended his little savings in an earnest endeavour to reclaim land, only to wake up to find himself unable to get the water he must have, and must have *now,* to save his crop from immediate destruction.

As far as it was humanly possible the Service sought to avoid these dire catastrophes, but human nature is urgent and insistent, impatient and self-willed, and public pressure was brought to bear upon officials, engineers and project managers to *hurry things up.* The people were clamouring for water; everybody could see it was running to waste. Why couldn't they have it? In a few instances they were allowed to have their way, only to come to a realization that, as the acreage of cultivation increased, it was more and more imperative that the permanent supply of water be put beyond any peradventure of a doubt. And the only way this could be done was by the enlargement of storage facilities. Larger dams, or new dams, must be constructed. This meant additional expense, ultimately to be borne by the consumer, the settler.

Sometimes it was discovered that the peculiar nature of the soil required far more water than had been supposed. Even tests and years of farming on one area of a project gave no clue to the conditions found to exist on some other part. A score, a hundred, new elements of inequality, or disturbance, were discovered, and, ere the project could be said to be in full working order, all these elements of inequality or inharmony must be removed or conquered, no matter at what labour or expense.

And nobly the officials, engineers and managers of the Service responded to these demands upon their knowledge, skill, ingenuity, tact, patience, and equanimity. Settlers who had started in to undertake great things with limited capital, and even more limited knowledge of what was before them and must be overcome, could not always see what was being done for them, and how much thought and care were required to remove the obstacles that, unexpectedly, had sprung up in their path. Unprejudiced outsiders can see and understand and they unhesitatingly commend the high public spirit, the patriotic adherence to unpleasant duty and the pouring forth of the scientific and practical knowledge of men who were seldom paid by the Government anything like the amount they could have received for less work elsewhere.

One of the unavoidable errors made in early days of all irrigation work—whether undertaken by engineers of the Reclamation Service or of other organizations, was the placing of the probable cost of the enterprise too low. There were no precedents for guidance and there was a steadily increasing demand for larger and better works than those at first contemplated. That is to say, if the original estimates were based upon wooden structures and the cheapest possible method, it was found that as work progressed and land values increased, the people interested made demands for a better type of work and for larger and more comprehensive schemes. While the pioneers were satisfied to drive across the canals and ditches, the next comers insisted upon having good bridges. While the man who built his own irrigation lateral was satisfied with any kind of rude device to control the water, his successor demanded from the Government officials the very best and latest pattern of water-gate, thus doubling or trebling the assumed cost.

It is a well recognized tendency of the human mind to demand the very best of machinery and service when furnished by a corporation or by the Government, and there is an equally strong or greater tendency to question or even repudiate the bill when ultimately presented for payment. Thus, it happened that while the landlords on the one hand urged upon the Government officials more and more expensive work, they were later equally insistent that they should not be called upon to pay for these added facilities and greater safeguards but that they should refund only what they regarded as the original estimates although these had been stated at the time as tentative in character only and pertaining to the relatively simple works then under consideration.

This question of the estimated cost thus formed a matter of much complaint. At the outset and throughout all of the operations the engineers of the Reclamation Service have at all times and on all occasions called attention to the fact that the estimated cost can be stated, as required by law, *only after* the work has been done and then "shall be determined with a view of returning to the Reclamation fund the estimated cost for construction of the project, and shall be apportioned equitably." The men who are ultimately to pay this estimated cost have tried to hold it down to the quantities which they allege were given to them informally during the period of discussion of the project. Moreover, under pressure of self-interest, many of them forget the qualifying statement made, for example, that the main works "will cost from $20 to $30 an acre, providing we do not build many permanent head-gates, bridges, and provided that the distribution system is constructed by the farmers themselves." In the popular mind, only the lowest figure of $20 per acre remains fixed and the qualifying clauses disappear during the somewhat heated discussion which has followed.

However this may be, there was so much to do, so many projects to be considered, so many gigantic plans to inaugurate, that it was impossible for any body of men to go carefully over all of the details and to foresee all the contingencies. Not being gifted with skill of prophecy, the engineers could not foresee the steady rise in prices and materials and labour, nor the decreased efficiency of labour due to its scarcity; nor was it permissible for them to assume that there would be unusual or unprecedented floods or catastrophes such as experience had not shown to exist. They could not safely predict that a great part of the land when reclaimed would not be immediately utilized and thus would fail to bring back its pro rata of original cost. Even had they foreseen clearly and accurately prophesied all of these conditions, they would have been in worse plight because no one would have believed them and they would not have been entrusted with the carrying out of the work.

These and other alleged mistakes of the engineers have been greatly exaggerated because they fit in with a very insidious doctrine which has been quietly promulgated, namely: that of ultimate repudiation by the land owners of the debt owed to the Government for bringing the water to the lands. While the local politicians appreciate that they would meet with no sympathy in the unequivocal proposition to repudiate, yet they very practically reason that if it can be shown that mistakes were made or that the final cost was underestimated at a period five or ten years before, then there might be a hope of inducing the Government to accept a less amount than was actually expended. This indirectly puts a cash premium upon proof of the engineers' incompetence or bad judgment and has resulted in many unfair attacks upon men who, from their official position, are unable to defend themselves or, because of proper self-respect, do not care to enter into a wordy war.

An example of the increase of cost to the ultimate payor of the bills, namely the farmer, over that at first assumed, is the Truckee-Carson project, the original estimate on the basis of works then proposed being $22 per acre to be paid in ten annual instalments. This was raised, to the lands first reclaimed, to $26 per acre; for other lands $30 per acre; and to the later comers who had the advantage of increased facilities, to $60 per acre. It should be noted, however, that this increase of charge for the use of the water is far less than the unearned increment in value of the land, which has gone to the land owner and has raised his property from being practically worthless up to conditions where he demands a hundred dollars or more per acre for the raw land simply because the Government has made it possible for water to be procured at any price.

Many similar increases over the first assumed or unofficial newspaper statements might be given but, to those who are not financially interested, the reasons are seen to be natural and beyond fair criticism.

Numberless difficulties of the most serious character arose from the failure of contractors fully to investigate conditions before putting in their bids; consequent inability to perform their contracts; the letting of sub-contracts to men of inadequate finances to carry the work through to completion; the coming of storms—blizzards, severe snowfalls, heavy rains, floods—to prevent progress; strikes of workmen; mismanagement; rises in prices of material and labour; unforeseen difficulties and conditions which led the officials of the Service, in honour, to change the terms of contracts; attachments on contractors' plants; delays demanding irritating extensions of time; unfulfilled promises of too-optimistic contractors; breaking down of machinery and difficulties experienced in making repairs at such long distances; accidents to workmen; disputes over claims for damages as the result of such accidents; inadequate equipment of contractors; the inability to secure sufficient men and teams on reasonable terms, and also to get enough to do urgent work on time, prior to the coming of surely-expected floods, frosts, storms, etc.; inability of contractors to realize the magnitude of the work they had attempted, etc., etc.

What a long list it is; things great, things small, things petty, yet all needing attention, wisdom, tact, and patience to overcome. Unforeseen difficulties constantly were arising, difficulties that it was impossible to foresee, any more than the expert engineers of America, engaged on the Panama Canal, foresaw the slides of the Culebra Cut. Nothing but actual work revealed these conditions. Of a similar character were the side hill slides on the St. Mary's Canal which led to abandonment of the affected portion, and its construction on the other side of the river. To the ignorant layman this seems a preposterous procedure. The water is taken out from the river on the side *opposite* to that where it is needed for irrigation, and then made to *recross* the river in an inverted giant siphon. In addition to this the construction on the "wrong" side implied building across the dry bed of a creek where sand, silt and rocky channels existed; the crossing of a fierce torrential mountain stream, and the final carrying of the waters of an 850 second-foot canal across the St. Mary River where, at the most favourable location, the structure must be over half a mile long and provide for a depression of about 175 feet and be carried across a bridge. Yet careful investigation and actual experience demonstrated that it was cheaper to abandon the work partly done, meet the difficulties named and incur the expense of crossing the river, than proceed on the line originally laid down.

Unforeseen difficulties wrecked the Pecos Irrigation Company, a private corporation, when great caves developed in the gypsum formation under a certain part of Lake McMillan, and this same condition rendered the abandonment of the Hondo Project necessary, as well as several reservoirs built in that part of New Mexico by private capital.

One of the great problems that confronts all engineers in the irrigation of large areas is that of drainage. The continuous inpouring of water raises the sub-surface water-table, causing boggy or marshy places, and sometimes creating ponds of considerable extent. Seepage also occurs, and this creates its own peculiar difficulties that are both tedious and expensive to overcome.

In some cases where the canals were found to be in very pervious ground they were lined with clay or cement as was deemed best. Then water users were urged to irrigate their land in the shortest possible time, be as economical as possible in applying the water, be careful about wasting water, and especially at nights, and to construct proper waste-water ditches. Main or trunk drainage ditches or canals were also provided.

The solution of the problems of drainage and seepage are of the intensest practical interest to the farmer, as upon them often depends the failure or success of his life-work, and to the scientific and technical engineer they are fascinating as giving him the material for mental conflicts which men delight in. Naturally in a nontechnical work of this character no attempt has been made to state the surface and drainage problems that have arisen on the various projects, but the interested reader will find them thoroughly presented in Director A. P. Davis's comprehensive book, *Irrigation Works Constructed by the United States Government.*

The most practical way of preventing the careless use of water, such as ruins 15 to 20 per cent of all irrigated areas is through "touching the vest pocket nerve." While the irrigator may understand and appreciate that he is using too much water, and is causing injury, yet the convenience of the supply or indifference to future consequences will result in his continuing the destructive process. If, however, he is told that he can use all the water he wants providing he *pays in proportion*, he quickly begins to take notice. This policy brought out by the engineers for the Reclamation Service has resulted in great advantage. On some of the projects, for instance, a man is permitted to have water at the rate of 50¢ per acre-foot for the first acre-foot applied to his irrigable land. For the next he is to pay 60¢, the total being a fair amount for the year or season. If he needs more he pays at a steadily increasing rate, say 20¢ for the next ¼ acre-foot, 25¢ for the next and so on up until the price of additional water becomes prohibitive.

It is wonderful to see how the attitude of the careless man changes under such conditions. He may have been using and claiming in good faith that he needed 6 acre-feet on his sandy land; when, however, he has to pay at an increased rate for everything over two acre-feet, he quickly discovers that he can not only get along with part of the water but can raise crops twice the value of those previously produced.

One of the problems that has arisen to disturb the lay minds of some of the settlers on the various projects has been the disposal of the natural springs that were found on certain lands, or that developed *after* the Service had installed its dams and distributing systems. Many legal opinions have been expressed in various States on this matter. There does not seem to be any unanimity of law upon the subject, but the Reclamation Service has insisted upon certain fundamental principles, two of which are that the *right* to the water from either type of springs depends upon its beneficial use, and that no right can be sold or disposed of; it can merely be exercised as an individual right "for use on the premises" for the watering of stock, domestic use, etc.

On the Sun River Project it was found that alkali was having an injurious effect upon some of the concrete work. One of the engineers while repairing a few culverts, attempted to replace a cracked 24-inch pipe. This pipe, on being removed, was found to be not only cracked but very much softened. Further investigation revealed that the entire culvert was in the same condition. Consequently, the pipe was all removed. This pipe, after being in the air for a time, hardened a very little. Further investigation showed that the concrete near the water-line was in the worst condition and that there was no difference whether the concrete was a dry mixture, such as the pipe was made of, or a slush mixture like the head-walls, or mortar. The water in this coulee was strongly alkaline.

The effect of the alkali on many of the pipes is most peculiar and quite distinct from disintegration in its familiar forms. The pipe becomes swollen and cracks, revealing a soft or putty-like interior. In other pipe and in most concrete in mass the surface seems to soften and scale off, resembling the weathering of a stone.

As a result of the alkali action above noted and similar action on several other projects, the Reclamation Service, in co-operation with the Bureau of Standards, the Office of Public Roads and Rural Engineering of the Department of Agriculture, and the Association of American Portland Cement Manufacturers, has been conducting for several years a thorough investigation of the effect of alkali on concrete.

The conclusion has been reached that the disintegration is caused both by the expansion resulting from crystallization of salts in the pores and by chemical action of the solutions with the constituents of the cement. It naturally follows and has been amply proven that porous concrete due to either lean or dry mixtures is most subject to disintegration, and that the remedy lies in making the concrete as dense and as near water-proof as possible.

Another difficulty of an entirely different character is where serious injury was caused to the lands of the settlers by the improper handling, inadequate engineering and faulty construction of a privately-owned canal which had prior rights over those of the Reclamation Service. Investigation showed that the Crown Butte Ditch Company secured their rights by private filing on 30,000 inches of the Sun River and was supposed to irrigate 6,500 acres. Their ditch crossed several miles of government land and they had no right of way. Their first flume was poorly constructed and after two seasons' use, half of it blew down and was replaced. Twelve years later the company built a wood-stave pipe to take the place of the flume, the water users in the meantime having operated the canal at their own expense and without any payment to the company. But now, owing doubtless to government activity, the company was galvanized somewhat into new life, and began to make improvements. But no adequate preparations had been made for needed and suitable drainage. In 1907 heavy rains occurred. The company's canal broke in several places and caused considerable damage to the right of way and the canal of the Reclamation Service,—in one place completely washing away a rip-rap spillway. The actual cost of the repairs caused by the failure of the Crown Butte Canal Company to keep its canal in proper condition was $3,986.85. It can well be seen that water-users under the Sun River project must be protected from such possible losses, and it was the work of the Director, Project Engineer, and Attorney to get this whole matter in proper shape before relinquishing control of the project.

Private rights of way often have had to be secured for the dams, reservoirs, canals, laterals, waste ditches, etc. These have also implied the rights for roads in order that ready access might be had for maintenance and operation.

The question of fences, bridges over canals, fords, etc., has been a most complex one, for obviously it was impossible to allow indiscriminate fencing, bridging or fording, yet occasionally, and for temporary purposes, these privileges seemed indispensable.

The Service has also laid out all County roads within a project after full consultation with the County officials. Most of the canals and waste water ditches were bridged, so as to make all the projects available for rapid settlement and development.

As soon as this was done and the roads and bridges dedicated to public use the maintenance, improvement and extension of them was turned over to the regular county organization.

Not only has the Service had to consider all the many and varied needs of the living; even the dead have presented problems that have had to be solved in a satisfactory manner. For instance in the Fort Shaw unit on the Sun River Project it was found that no reservation for cemetery purposes had been provided, although a cemetery had been maintained since the establishment of the military post,—forty years before. The Supervising Engineer therefore recommended that this actually existent cemetery to the extent of ten acres be formally set apart for the use of the settlers of the Fort Shaw unit.

Many of the problems would have been much simplified had there been no settlers until the projects were actually completed and ready to be turned over to them. But this was impossible under the law as it then existed. This law has since been radically changed.

The government officials have, however, to a limited extent, counselled prospective settlers as private landowners often do seeking purchasers, although such counsel has been largely disregarded. With the private capitalist it is good business to see that every settler is located where he is sure to be satisfied. Private capital has long since learned that a helping hand to a genuine worker is often a real benefit. Banks extend credit; merchants allow farmers to get into debt deeply for implements, and in most cases they find the help materially beneficial and an incitement to higher endeavour. Private capital is generally ready to advise with those who come to avail themselves of opportunities afforded, and guides them as to what they may, or may not reasonably attempt. Similar advice has been given by the Reclamation Service through its Settlement Section, in recent years, even though a free-born American citizen, or one that had become naturalized, *might* and often did resent and disregard it. It was unquestionably good business to tell a clerk, who, with his family, was longing to leave the shut-up life of the city and move on to a piece of land in the arid West, that he would need a good deal of money, a great amount of optimism, a tremendous amount of persistent energy, a never-failing power for work, a courage that no amount of disappointments and failures could kill, or he ran the risk of never becoming a farmer, and of losing every cent of the earnings of a life-time that he was going to put into his venture.

Yet the question is still asked, what concern of the Government is it that city wives might break their hearts in the lonesomeness of the new surroundings; that the children, used to the noise and bustle, the association and perpetual excitement, of the cities, would soon be weary of, and hate, the steady, monotonous, and comparatively lonely life of the western farm?

In recent years the Reclamation Service has come to realize the great difficulties that would beset even the thoughtful who *had* fully considered for themselves, when the barren first years were encountered. It is during the first five years, or so, that the settler on new land needs help and encouragement. The officials, however, *thought* the settlers should be able to pay back the costs of constructing the vast irrigation systems in ten years, and it seemed a reasonable thing to require that the payments should be made in ten equal annual instalments.

But practical experience demonstrated in a short time that, in many instances, this was utterly impossible. Moving upon the land, building houses, barns, stables, however modest and economical, bringing one's family, purchasing stock and needful tools, seeds and trees for planting, clearing, levelling and planting out the land, preparing (as had to be done in some places) the farm laterals, making roads to connect with the turnpikes, and a thousand and one small things, yet, which, in the aggregate were large, completely exhausted the finances of many who thought they were extra-forehanded.

Yet the demands of the law were imperative. No mill of the gods grinds more surely than a rigid legal system, where wise judgment is hampered by legal restrictions. The result was that although extension of time was provided by not declaring the projects completed, yet it was deemed wise by Congress to lengthen the time of repayment of construction costs from ten years to twenty years. The first payment required upon entry was made sufficiently large to insure good faith on the part of the applicant, and—then assuming that the entryman would expend his funds in improvements—during the next few years the amounts to be returned to the Government were very small, the rate being increased so that the heavier payments come toward the end. This extension of time was greatly appreciated, especially by those who entered upon public lands. In cases of purchases of private lands, however, the results have been to increase the price demanded of the newcomers because of the fact that the Government's requirements were lessened.

CHAPTER V

AIDING THE SETTLERS

What a mixed flood of humanity it was that poured upon the arid lands as soon as it was known the Government was going to spend a hundred millions and more to reclaim them. And with what mixed motives they were animated. Yet all, in their own way, were in pursuit of happiness. Some didn't want to work, nor did they intend to, but they wanted one of Uncle Sam's farms that were to be had for the asking. On the other hand most of them were earnest home-seekers, desirous of bettering their condition by being established on the land, and willing to work to bring that desirable aim to accomplishment. That earnestness of purpose, however, did not subconsciously render them aware of the hard work ahead of them. Experience is the great teacher of us all, and in our processes of learning we are inclined to become impatient, critical and fault-finding. But in spite of this the attitude of the project managers, in the main, has been that of kindly helpfulness. That was the spirit of all the early day leaders, and well has it been passed on to those who lead today. Although governments advance slowly in the direction of social service, it is a source of great gratification that they actually are advancing, and this forward movement has been aided wonderfully by the activities of the officials of the Reclamation Service.

As far as possible, in the earlier construction, settlers and their teams were engaged to help in the work. This did not always work out to the best advantage, but the engineers were instructed to do it whenever possible. Sometimes work was postponed to give the settlers the opportunity of doing it. Thus thousands of dollars on the various projects were put into circulation.

As early as possible Demonstration Farms were urged by the project managers. Yet the Service did not wish to take away from the respective States the responsibility for the organization and control of such farms. Hence the question presented difficulties which stood in the way of ready and practical solution. In some cases, however, the Project Engineers, in consultation with the settlers and the State authorities, determined to do what seemed feasible in furthering this helpful work. Permission was found for this in the Reclamation Act which authorizes certain examinations of the soil, etc., needed as an essential basis of construction and maintenance of irrigation works. And in the Act of June 30, 1910, making appropriations for the Department of Agriculture, provision is made under paragraph "General Expenses, Bureau of Plant Industry," "for investigations in connection with the utilization of lands reclaimed under the Reclamation Act, and other areas in the arid and semi-arid region," and the sum of $76,680, is appropriated therefor.

This work has been of great value to the settlers and farmers upon the projects, in aiding them to determine what was best to grow, and how best to grow it. Even in growing the simplest of crops many of the settlers needed instruction, and those who were well-informed and had had large experience have been materially aided. In many places, new crops, such as sugar beets, have been introduced.

Later an expert Superintendent of Farming has been engaged, and he and his assistants have regularly visited the projects, counselled with the farmers, and not only given them advice, but in many instances have gone on to their farms and demonstrated how things should be done.

Much has been done to teach farmers how to irrigate their farms *properly.* Irrigation is a science, as well as an industry, and those who have thoroughly studied it and had large experience have been sent out to demonstrate how water should be applied to the various crops; how to avoid using too much water—for too much is almost as injurious as too little—and how to secure the most profitable results. The importance of this phase of educational and helpful work cannot be over-estimated.

How to cope with pests and destroy them has formed another important branch of educational work, and settlers are gradually waking up to the necessity of scientifically fertilizing their lands. The proper use of barn-yard manure; the relative values of commercial fertilizers; the crops that can be "turned-under" for the nourishment of the soil, and matters of this kind are constantly presented.

Farmer's Institutes are held where project managers, scientific irrigators, farmers, chemists, dairymen, etc., meet the settlers and give them helpful instruction upon these many and varied lines.

To provoke and promote co-operation, mutual understanding and helpfulness, true solidarity and gregariousness, the community spirit and pride, have ever been aims of the leaders. "Get together" conferences of all kinds have been held; the project engineers and managers generally have sought to gain and keep the good-will of the settlers and landowners by a furtherance of their best interests; visiting experts in irrigation, fertilization of soil, rotation of crops, choice, purchase and care of stock, harvesting, care and marketing of fruit, vegetable, dairy and other products are but a few of the activities in this direction.

Nor are the women and children neglected. They have been encouraged to form clubs of every helpful kind, and to promote tree-planting, flower-growing, a study of the economic value of the birds found in their localities, how they might help in sorting, preparing and packing produce for market, canning fruit and vegetables, and other similar activities.

In this they have been greatly aided by the sympathetic activity of Mrs. Louella Littlepage, who for many years has devoted much of her time, consistent with other duties in the Reclamation Service, to the study of these matters and has given advice not only by letters but by brief and newsy notes in the *Reclamation Record.*

Who can estimate the wholesome effects on hundreds and thousands of families such endeavours must produce? Animated by this spirit of practical brotherhood the nation has become the beneficiary of these altruistic efforts, by having its citizens bound closer together in more enduring ties.

The Water Users' Associations of the various projects are formed of the settlers, farmers, and landowners who claim the right to the use of the water provided by the project, and who live on its lands. The associations are formed to assure the Government that the landowners will apply for water from the irrigation works when they are ready for service, and that they will so adjust the existing claims to the use of water that the administration of all the water available for the lands under the project, whether supplied from private or from government irrigation works, shall be under one control, that of the water users, themselves. In conformity with Section 6 of the Reclamation Act, the management and operation of these irrigation works shall pass to the owners of the land irrigated thereby, when the payments required on the Construction Costs are made for the major portion of the lands irrigated from the waters of any of the works thus provided. While the Water Users' Associations now established cannot be recognized by the Secretary of the Interior as the corporation contemplated by Section 6 of the Reclamation Act, because the time fixed by law for the turning over of the irrigation systems has not arrived, yet they are being prepared for the duties of management and operation of these irrigation works, since their form of organization is made with this end in view. Under the Reclamation Extension Act the Water Users' Associations may be designated by the Secretary of the Interior as fiscal agents to collect the building and annual operation and maintenance charges on each project. Each share in the Association represents the water right for one acre of land; and necessarily each share-holder must be a homesteader or owner of land receiving water from the irrigation works. Such stock of water-right becomes part of and attaches to the land, and can be conveyed only by conveying title to the land. Each homesteader or owner of land receiving water from the canal is obliged to subscribe for as many shares in the Association as he has acres of irrigable land, limited, however, to a total of 160 shares. He must also be a resident upon the land or live within the neighbourhood thereof (within fifty miles), and if an entryman upon a homestead, he must comply with the provisions of the homestead laws. Those owning more than 160 acres of land receiving water from the government canals are prohibited from purchasing a water-right for an acreage in excess of this amount. For the protection of such owners, it has been arranged for the Association to hold in trust the amount of land which they own in excess of 160 acres until it can be conveniently sold as directed by the Secretary of the Interior, or requested by the owners themselves. The Association further assumes all the duties of levying and collecting the charges against the land and of making suitable contracts with the water users, subject to the approval of the Secretary of the Interior.

In some cases the Water Users' Associations have not taken much active interest in the work of their respective projects. This seems to be poor policy. Though the Reclamation Service officials and engineers are now controlling the maintenance and operation of the plants, it is certain that they cannot always continue to do so. When the time comes this work will devolve, perforce, upon the actual owners of the land and the works. Should they not, therefore, as early as possible avail themselves of the scientific and practical knowledge of the project managers, so that when the systems come under their control they may know how to run them in the most intelligent and profitable fashion?

Elsewhere I have spoken of the development of electricity upon the projects, that already accomplished, and that made possible in the future. It is beyond the ken of man to approximately conceive what this will mean to the farmers and their families when it is utilized to the full. There will be electricity and to spare for lighting, cooking, and heating. Fans, sewing-machines, churns, sawing-machines, lathes, grindstones, pumps, and a thousand and one labour-saving devices will be in operation wherever the electricity is forthcoming. Thus much of the drudgery of farm-life will disappear; our boys and girls will not flee from the farms because of their burdensome labour and tedious monotony. With electrically-propelled vehicles (by no means a remote possibility), they will be able to visit each other, riding over the finest kind of scientifically constructed roads, and when night time comes, they may meet in common assembly halls where moving pictures, stereopticon lectures, concerts, entertainments, dances, and the like will satisfy the gregarious instinct that seems to be implanted in every human breast.

Let me caution the reader, however, against supposing that the aim and work of the Reclamation Service clears away all difficulties and discouragements from the path of the settler. There are many obstacles in life that no man or body of men can foresee, prevent or obviate. In reading the project histories I find accounts of killing frosts, unexpected floods, caused by sudden and unexpected rains, cloud-bursts, or melting of the snows, windstorms, grasshopper pests and other misfortunes that act as set-backs and often cause serious discouragement.

These, however, are the acts of what we call Nature, and all men must bow to them, make the best of them, triumph over them, or succumb and go under. There is no other way. The Reclamation Service plans and purposes to help as far as it may and can; the Weather Bureau adds its knowledge of climatic conditions to give advance information and warning that will provide added security to the farmer, stockman and fruit-grower, but no man must expect that his life will be free from all burdens, set-backs, responsibilities and struggles. The life to be desired, however, is that which avoids and is free from all *preventable* annoyances and difficulties—and this the Service seeks to promote in every way—and then, whatever else comes, let each man rise in his own divine might, and, by the power of his unconquerable soul, triumph in spite of all that may seem to be against him.

Far more difficult than the battles with Nature are those in which the patriotic settlers must join with the Reclamation Service in contending for high moral standards. In my book on the *Heroes of California* I have told of the magnificent fight and splendid spiritual victory won by Major John Wesley Powell over the politicians and speculators. It is to be by no means assumed that these men have quietly accepted defeat. On the contrary they and their kind are always with us and when beaten in the open retire to ambush. The same kind of battles are to be fought in different ways; all along the line eternal vigilance and resistance to wrong is the price to be paid for continued high principle.

It is no longer a question as to whether or not the public lands should pass directly into the control of the speculators. That contest has been settled by the United States taking charge of the reclamation of its lands and by offering inducements for the subdivision of the privately owned lands and the putting of these into the hands of actual settlers. It has advanced the money on the assurance that this will be returned to be used over again to reclaim other lands and benefit other settlers. To secure this return it has sought many safeguards, but these can not be fully effective unless supported by a high moral stand on the part of the public, and especially of the men who have been benefited and who should be willing to do their part in permitting others to share in similar benefits.

Here is where the petty politician and speculator in lands sees his opportunity. While he would not risk his chances of raising a storm of general protest by urging direct repudiation of the amount owed the Government yet he has seen that he can secure a certain amount of popular approval by more cunningly devised schemes such as will defer the repayment and secure to the men who are trying to sell land an extension of time by means of which they can increase their prices and secure for themselves unearned increment of value of the land.

This is easy to do. There are plenty of instances of real hardship, of misfits on the farms, such as necessarily occur when a large miscellaneous population drifts into a new country. While the majority may be fairly prosperous there is always a minority who must necessarily fail. Among these are a few who would be far better off in some other occupation. By exploiting the disappointments of these people and by encouraging complaints from the ne'er-do-well, it is easy at any time to raise a great volume of sound. While most of the farmers are busy in their fields earning the necessary money to pay their debts, a vociferous crowd of idlers may assemble in towns and clamour for relief.

Moreover, it is always very easy to demoralize a community by free gifts, whether it be of seed, of literature, or of public buildings. Once inoculated with the germ the unthinking crowd cries for more. The conception that some one must pay for these gifts, and that true citizenship demands that the beneficiary do his part, is kept in the background.

The great contest demanding far stronger moral fibre than that needed in battles with Nature is now being waged by the strong men of the Reclamation Service aided by the larger minded citizens on each project—in trying to keep down this popular wave of repudiation and to expose the insidious forces working through a community. It is so easy for some one speculator, or politician, to start the cry that "we are willing to pay a *proper* cost for the works" and then show that this portion, or that portion, was not absolutely necessary, or to allege extravagance. The engineers who have devoted the best part of their lives to this work and who may have achieved notable results in economy and efficiency, are no longer in sight, or can not defend themselves from attack. Even if extravagance cannot be proved, yet as before stated, there are plenty of cases of misfortune among the irrigators, and because of one or two of these pitiable instances an indefinite extension and ultimate reduction of cost is demanded.

While no right thinking man desires to oppress any individual and while each is willing to recommend an indefinite extension in deserving cases yet there is no proper excuse for using these few cases as a reason for action which will prevent those irrigators who can do so from making payment and returning to the Government the money which has been used for them and which in turn should be beneficially employed for others equally deserving. The general public, however, who might be benefited, has no immediate representative in this matter, other than the conscientious officers of the Reclamation Service. These inheriting the spirit and vision of Major Powell must each fight out the same old question as to whether he will take the easy course and win immediate applause or tread alone the difficult path pointed out by their great guiding predecessor.

We may confidently predict, in the long run, a victory and the overcoming of the forces which are continually at work nibbling away the reclamation fund. Assuming that it can be preserved in its integrity and used again and again we may look forward to the building of other large projects and of still wider aid to deserving settlers. There are innumerable opportunities and instances even greater than those described in this book. The vision of great usefulness still inspires the men who have consecrated their lives to this great mission. They need and deserve the whole-hearted support of every one, in their fight for the maintenance of clean administration and of high but practicable principles.

CHAPTER VI

IN THE LAND OF THE GIANT SAHUARO. THE SALT RIVER PROJECT, ARIZONA

This was one of the first projects upon which work was actually begun after the passage of the Reclamation Act. It is one of the largest, as far as acreage to be reclaimed is concerned; it is the most spectacular, perhaps, of all the works of the Reclamation Service, owing to the location of the great Roosevelt Dam in the wild, rugged and picturesque Salt River Canyon; it is the best known, owing to the fact that its storage dam, with the consequent reservoir, and the adjacent town all bear the name of the president who signed the Reclamation Act; it is the most romantic in its environment, as it is located on the famous "Apache Trail" in the very heart of the country made memorable as the secret haunt of those scourges of the white race, the warlike Apaches.

Possibly nowhere in the world are the advantages of governmental works of irrigation on a large scale so evident as in the Salt River Valley. For years casual travellers had reported the existence of ancient irrigation canals, and in the seventies and eighties Lieutenant Frank H. Cushing, of the Bureau of American Ethnology, asserted that these canal ruins, with the Casa Grande ruins, and other remnants of cities or communities, demonstrated the fact that at one time a vast sedentary and agricultural population occupied a large part of the Salt and Gila River Valleys.

It was later found that at least eleven main canals existed, and in the neighbourhood of 135 miles have been actually traced, which were capable of watering upwards of 100,000 acres of land. It may be said in passing, that it was these prehistoric canals and cities that gave the name to Phoenix—a city rising out of the ashes of its forgotten past—later to be the capital and metropolis of the State, and the commercial centre of one of the most productive valleys of the world.

In due time careful investigation by agricultural experts confirmed the judgment of the pioneer locaters, that the soil of this valley was admirably adapted for the growth of every kind of tree, plant, fruit or vegetable that was found in any country of earth except those that were purely tropical, and the climate was ideal for rapid and perfect growth. The natural result was that, as soon as the mines began to be actively worked, prospective farmers located in the Salt River Valley, tapped the Salt River with canals, and commenced operations. The first canal was known as the *Swilling Ditch,* from Jack Swilling, one of the pioneers who had been a Texas Ranger, and came to Arizona in the early sixties, with the Walker party that found placer gold near Prescott. Visiting John Y. T. Smith at Fort McDowell, he there saw the agricultural possibilities of the valley and organized a company at Wickenburg. From this little nucleus has grown the Phoenix of today.

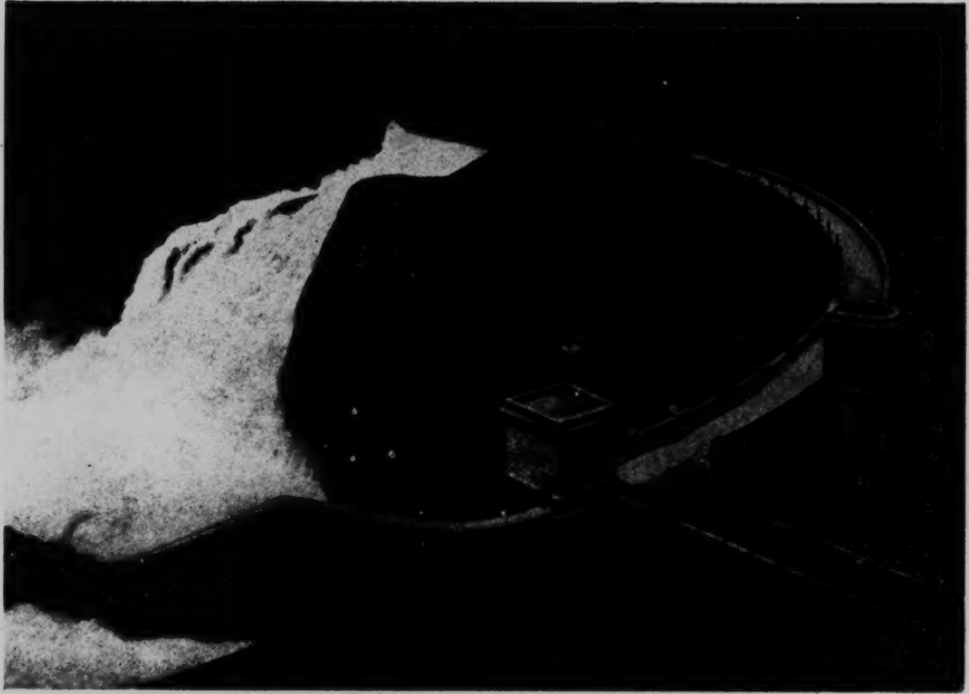
A part of Swilling's ditch later became known as the *Salt River Valley Canal,* and another as the *Maricopa Canal.* From 1870 to 1894 various other canals were built, the principal ones on the north side being the *Grand* and the *Arizona,* the *Cross-Cut* connecting these two. On the south side were the *Tempe, San Francisco* or *Wormser, Utah, Mesa, Consolidated,* and *Highline.*

The diversion for the Arizona Canal was made by means of a timber-crib rock-filled dam covered with heavy planking. The other dams on the river were temporary affairs of brush and rock, that were usually swept away more or less completely by the periodic floods that occur in the river with great certainty. After the floods these dams could not be repaired until the river had reached a comparatively low stage, with little water available for irrigation, and as a result, the valley was generally in a state of water famine.

The outcome of this condition can be conceived only by those familiar with the imperative need for water in the hot weather. Given the water, growths seem miraculous; without it, the destruction and reversion to desert is equally miraculous in its speedy operation. The irritation, desperation, and despair of men who saw themselves ruined by a shortage of water led to innumerable quarrels, for careful observers were convinced, as early as 1854–5, that the farmers could not rely upon more than the low-water flow of the river, and that even this was jeopardized by the shortage that invariably followed the destruction of the dams during flood-times. During the period from 1890 to 1899 the shortage of water was very pronounced, and some of the cultivated land reverted to desert. These things naturally retarded the development of the Salt River Valley, and led its citizens to cast about for means to remedy the evils. Litigation, which seemed without end, clogged the courts, feuds were started, some of which came near to being deadly, while the sane and sensible conferred with each other and determined that there was but one basic solution to the problem. This was *more water,* and *more constant or steadily-flowing water.* This implied the creation of a storage reservoir of sufficient capacity to supply all needs throughout the agricultural year, and the organization of a system of distribution that should eliminate all local quarrels, be uniform and equitable to all concerned. To accomplish these desirable and essential results, however, implied an expenditure too vast for private capital. The County and Territorial governments were called upon—for Arizona was not yet raised to the dignity of statehood—and reconnaissance examinations and surveys were made.

In the meantime the perpetual litigation was more and more emphasizing the need, the absolute necessity, for pulling together and eliminating the expensive, irritating, and generally useless "lawing." In 1900 the citizens of Phoenix organized a water-storage committee for "promoting investigations and developing some project for the storage of water." Major Powell's known sympathies were called upon for aid, and in 1901, Mr. Arthur P. Davis, now Director and Chief Engineer of the Service, made further investigations of a most rigid and scientific character.

In June, 1902, the Reclamation Service came into



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ROOSEVELT DAM AND NORTH SPILLWAY
SALT RIVER PROJECT, ARIZONA

existence. Everything was ripe in the Salt River Valley for its taking the loose threads of many canal corporations, and private individuals, which were never in any other than a snarled and tangled condition, smooth them out, put in the necessary storage system, an effective and economical distribution system, and thus put an end to the irritating causes that had retarded the development of the country. At the same time the Reclamation Service could test its worth, prove its mettle as it were, by constructing a model plant which would make possible the irrigation of many thousands more of acres, and therefore attract a large influx of new settlers to this divinely-blessed land.

Coincidently Mr. George H. Maxwell, immediately upon the conclusion of his long and successful campaign in the aid of Mr. Newlands and the President in getting the Reclamation Act passed, began systematically to initiate work to smooth conditions in the Salt River Valley. As an experienced lawyer he saw the legal difficulties and appreciated that nothing could be done without the active help of all concerned. He put his splendid energy at the disposal of the Water Users' Association, backing up the efforts of its President, Mr. B. A. Fowler. They and innumerable assistants started in on a long and difficult campaign to win over and adjust the private interests. To record how this was done and to narrate the schemes, the diplomatic victories and to properly characterize the tact, skill and judgment combined with practical wisdom that were brought into exercise would require a book larger than this and be perhaps even more interesting.

The Reclamation Service eagerly undertook the arduous task. The preliminary work already referred to had satisfied the engineers who were now at the helm in the newly organized service (to which they had been transferred), that a storage dam should be constructed on the Salt River at a natural site near the mouth of Tonto Creek, which should yield water for the irrigation of all the privately-owned lands of the valley, and that electricity should be generated at the reservoir for the pumping of water from wells. This plan was recommended to the Secretary of the Interior, with the further proviso that negotiations be initiated with the owners of existing canals, and of the land, to the end that every conflicting interest could be merged into one harmonious and successful whole.

In March, 1903, the Secretary approved the plans, and in the same month the Salt River Valley Water Users' Association was organized, whose articles of incorporation were also approved, and with whom a contract was signed by the Secretary in February, 1904.

Now the reader is ready for a few facts about the water conditions and the work to be done. The project is located in Maricopa and Gila counties. The sources of water supply are the Salt and Verde rivers, and wells in the Salt River Valley. The area of the Salt River drainage basin is 6,260 square miles, and that of the Verde, 6,000 square miles. The annual rainfall on the irrigable area is seven inches, while the annual run-off of the Salt River, (at Roosevelt,[1] with a drainage there of 5,760 square miles) from 1888 to 1907 was, maximum, 3,260,000 acre-feet; minimum, 154,000, or a mean of 804,000; while the Verde River at McDowell, from 1888 to 1908, gave a maximum of 1,858,000; minimum, 117,000; or a mean of 586,000 acre-feet. This gave a mean of the two streams of 1,390,000 acre-feet, per annum.

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[1] It is interesting to note that from 1889 to 1914 the maximum run-

The plan, however, contemplated the erection of only one *storage* dam, that at Roosevelt. Here the site was chosen by Nature. A very short distance below where Tonto Creek flows into the Salt River from the north the latter pours through a narrow gorge into the canyon of the Salt River. It is a wild, rugged and picturesque spot, and when the river was at flood, the Tonto-Apaches, of the old days—who were the aboriginal residents of the whole surrounding country—were treated to a scene of turbulent waters almost as grand and awe-inspiring as their aboriginal brothers in the North were in the habit of witnessing in the Grand Canyon of the Colorado River. To create a dam here of sufficient power to stop and tame the Salt River, especially at flood-time, meant a gigantic piece of solid engineering. As completed it is 280 feet high, 1125 feet long, with an automobile road across the top, sixteen feet in width. There are 342,325 cubic yards of masonry in the structure. To build such a massive dam would have been regarded as a great work, in the heart of a city, close to quarries and with every method of transportation readily available. But to accomplish such a task in the heart of a desolate, mountainous coun-

off at Roosevelt was 3,226,470; minimum, 153,394, with a mean of 772,052 acre-feet; and of the Verde for the same period, maximum, 1,801,500; minimum, 116,679; mean, 562,065 acre-feet.

try, seemed almost impossible. The site of the dam is about forty miles from Globe on the east, and about sixty miles from Mesa, on the west, the latter being the nearest railroad station in the Salt River Valley. There was no road from either point to the dam. Railroad rates to Globe were very much higher than those to Mesa, and after careful investigation it was decided to build a wagon road from Mesa to Roosevelt, over which necessary supplies and materials for building the dam could be transported. The cities of Mesa and Phoenix contributed by a bond issue about $70,000 towards the construction of this road.

It is one of the romances connected with this highway that many miles of it were built by the Apache Indians, and that they were found to be such reliable workmen that they were sent out in squads, or bands, without any white boss or time-keeper than their own inherent sense of honour. This sixty miles of road is now a part of the world-famed "Apache Trail," over which thousands of American and other travellers are being conveyed annually to their intense delight.

At the inception of the project bids were obtained from the leading manufacturers of cement for 200,000 barrels—the amount that it was estimated would be required. These bids showed that the cement would cost heavily at Globe, and that this cost would be so much increased by hauling to Roosevelt that the price would be $9.00 per barrel. This price was prohibitive, as it added practically $1,100,000 to the cost of the project. The engineers, therefore, began to look around for a way out of the difficulty. They found on the mountains above the dam site a large limestone ledge, and at the foot of the mountain an ample supply of blue clay, both of which are necessary to the manufacture of a high grade of Portland cement. The Service thereupon announced that it would erect a cement mill and make its own cement. This called forth a vigorous protest from the manufacturers, who requested that another opportunity be given them to offer bids, which was done, and the price was then made of $4.70 per barrel, delivered at Roosevelt. As careful tests, however, demonstrated that the Service could manufacture the cement on the spot for $2.20 per barrel, including the cost of operating the plant, the Secretary of the Interior rejected all bids and authorized the erection of the mill. This was done at a cost of about $123,000 and it worked daily, turning out about 400 barrels per day, until the work on the project was completed. Between twenty and thirty thousand barrels were also hauled from Roosevelt to Granite Reef, near Mesa, for use in the construction of the diversion dam that was simultaneously being built there. The small cost, too, led to the use of some 20,000 barrels more of cement in the Roosevelt Dam than otherwise would have been used, naturally strengthening its construction and rendering it far more durable.

Economy had to be practised in every way, as the whole country—Congress included—was watching operations with interest, and upon the economy or extravagance shown in this great work the Reclamation Service would be judged. A vast amount of lumber was needed. A fine pine forest was found in the Sierra Ancha Mountains, some 4,000 feet higher than the river. A small mill of the portable type was purchased which sawed some three million feet of lumber. This was hauled over a wagon road, especially built, to the various locations along the canal where it was needed. Some $15.00 per thousand feet was saved by sawing this lumber in the mountains, even after taking into account and charging to the lumber, the entire cost of the road and sawmill, less the small sum for which the sawmill was sold later.

In placing the giant rocks in the dam, and for the conveyance of the thousands of tons of concrete required in the structure, a large amount of power was needed. How to secure this cheaply was a grave question. It was decided to bring in water a distance of thirteen miles in a canal, to be used for the generation of electric power. While this canal was being completed, it was necessary to run a steam engine to manufacture cement for local use, and to do a number of other things required in any camp where construction work is going on. Although it was but a relatively small plant, it required a pile of wood four feet high, four feet wide, and from a mile and a quarter to a mile and a half long *every month,* and nearly all this wood had to be packed on burros' backs from one to ten miles. It was not only difficult to get the wood, but it was becoming pretty expensive by the time they were able to turn the water from the power-canal through the water-wheels.

This power-canal generated all the electricity required by the contractors for power during the construction of the dam, and the low price they bid for their work was owing to the fact that the Reclamation

Service charged only half a cent per horse-power hour up to 400 H. P., and above that one cent per horse-power hour. This cost was about one-eighth to one-tenth of what the contractors would have been out had they hauled oil from Mesa, or cut and hauled wood for the generation of power from the rapidly diminishing supply near the dam.

A large number of teams were required to do the needed work, haul supplies, etc. To keep them busy all the time required careful planning. This was accomplished as follows. There were several farms in the valley, occupying the reservoir site, which had to be purchased, as they would be flooded as soon as the dam was completed, and storage of water began. When teams were not otherwise engaged they were set to work on these farms, and in the first year of operation, they showed a net profit of about $9,000.

As I have before explained, the Tonto Basin, which is flooded by the Roosevelt Reservoir, was once the home of the Tonto Apaches. Large numbers of these Indians were used on the preliminary work and during the entire construction of the dam. In answer to my queries on the work of the Indians Mr. Louis C. Hill, the Supervising Engineer, sent me the following interesting particulars:

> When we first began to hire these Indians they were a wild-looking lot and had to be treated very differently from the ordinary whites available. Within a short time, however, they dressed very much as the white or Mexican labourer. About the only difference that could be noticed between the Apache Indian and the white man or Mexican, was that the clothes worn by the Indian showed the result of frequent washing, while the clothes used by the hobo

white men and Mexicans had no such marks. At first, many of the foremen were prejudiced against Indian labour, and I remember during the early part of 1905, when the floods in the river had prevented some of the work going on, a large number of Indians were thrown out of employment. Just at this time an equally large number of White Mountain Apaches came down to the dam, probably driven out of their homes by the hard times, the result of the years of drought preceding the big floods of 1905. A conference was held with their chiefs, at which many of the Indians and their families were present. The only thing for which the Indians asked was the opportunity to work, although I knew that a number of them were suffering from lack of food, and that the whole tribe was living largely on rats, mice, and the small game that could be found in the neighbourhood. After the conference had progressed a little while, one chief of the Tonto Apaches, Yesterday, by name, gave a very impressive talk lasting for two or three minutes. The interpreter translated it as follows:

"He says that when he was young, General Crook came into the country and took the Indians all away from the Tonto basin and took them to San Carlos and put them on a reservation there. Now they had been permitted to come back to the country that had once been theirs, and they thought that if there was work they ought to be given a first chance at it, rather than to give the work to the Mexican and to the hobo white."

I told him that I thought his contention was a good one and he certainly should have work, along with all of his people who needed it, and were willing to work. We used the Apaches in the construction of roads and on all kinds of work, and I do not know of any better class of workmen or unskilled labourers than these Apaches proved to be. They were especially valuable to us in view of their ability to maintain themselves without an elaborate camp in some of the out-of-the-way places where it was with the greatest difficulty that we were able to pack stuff to them.

ORANGE GROVE NEAR CAMELBACK MOUNTAIN
SALT RIVER PROJECT, ARIZONA

CULTIVATING IN YOUNG ORCHARD ON THE GRAND MESA
GRAND VALLEY PROJECT, COLORADO

Merely to mention one of the minor items, showing the difficulty of doing the work in this remote spot, I recall that when the men were working on the road at the top of the Fish Creek Hill, before the summer rains, it cost the Service twenty-five cents per day per man, to haul drinking water for their use, as it all had to be packed on mules.

I have entered thus into somewhat particular details about several matters to give the reader some idea of the obstacles the supervising and project engineers had to overcome. The accomplishment of a great task is often far easier than the building up of the organization with which it is to be done. In the beginning of its work the Reclamation Service had neither the men, the experience, nor the organization.

As before explained the Roosevelt Dam is for the purpose of storing water until needed. The water backs up for a distance of 24 miles, with an average width of one mile. At its deepest the reservoir is 225 feet deep, and it covers 16,832 acres with a capacity of 1,367,300 acre-feet. This vast reservoir and its surroundings, has now become a national pleasure park. The Southern Pacific Company is erecting a magnificent and commodious tourist hotel on a point quite close to the dam, and in the temporary villa near by, scores of people stop daily as they ride over the Apache Trail, or come for a week, a month, or even a longer vacation. For the reservoir is well stocked with gamy fish; there are power-boats, sailboats and row-boats in number to be hired; near-by are wonderful cliff-dwellings, many of which are only recently discovered, and there are places where deer, antelope, mountain-lion and bear may be hunted, as well as a score most romantic, picturesque and wonderful spots where fights with the Apaches have given an added interest to places that are as striking in their scenic qualities as any of the famous attractions of the continent.

Instead, therefore, of the water of the Salt River flowing irregularly as it did prior to the erection of the dam, sufficient is allowed to escape daily for all the required needs of the many ranchers in the valley below. From this dam to the Granite Reef Dam, which is four miles below where the Verde River empties into Salt River, the water flows in the old bed of the river itself. This dam receives its name from a great reef of granite on which it is placed. It is of rubble concrete weir type, with a maximum height of 38 feet, and a length across stream of 1,100 feet, and diverts the water to the systems of the North and South Side canals.

In addition to these dams, there have been put into operation nine pumping-plants, with an approximate capacity each of ten second-feet. One pumping-plant, located at the junction of the Western Canal and the Kyrene branch, pumps water through a 54-inch pressure pipe 5,930 feet long to an elevation of 40 feet, and waters approximately 7,500 acres of land. All the electric power used in these plants is generated at Roosevelt Dam by water from the reservoir.

The canal- and lateral-system of distribution comprises 815½ miles, and on the completion of the entire project will provide for the delivery of water to each 160-acre tract of irrigable land in the over two hundred thousand acres of the valley.

Irrigation is carried on 365 days in the year; the average rainfall is approximately eight inches, while the average elevation of the irrigable area above sea level is 1,200 feet.

The original contract between the United States and the Salt River Valley Water Users' Association provided that the United States could not open the project until after the completion of Roosevelt Dam. As the time of the completion of this dam grew nearer and nearer, the people in the Salt River Valley felt that something should be done to postpone the time when payment must begin, and accordingly a contract was entered into by the United States and the Water Users' Association, whereby the latter agreed to build three power-plants in the valley and do certain work up to an estimated cost of $900,000, provided the United States would extend the opening time of the project at least two years. These power-plants were to become the property of the United States as soon as completed. The Water Users' Association fulfilled its part of the contract. The power-plant at Roosevelt that was used to build the dam was added to until now its capacity is about 10,000 K. W., or 13,000 H. P. The capacity of the plants in the Valley is from seven to eight thousand horsepower. Several years ago contracts were entered into selling practically all the power, except that which was reserved to fulfil certain contracts and for pumping. The plant is not entirely completed to date, but the revenue received for the months of May and June of this year are about $36,000 for May and $39,000 for June, or net, about $28,000 and $31,000.

For the next twenty years, therefore, these power plants each year will pay all that portion of the assessment against the project due to their cost and will reduce that part of the payments for the strictly irrigation portion by a very large percentage. After the project is paid for the revenue from these plants will not only pay the entire operating expenses of the project but will leave a handsome surplus for dividends or for further construction and improvements.

Owing to great floods that came down the Salt River in November, 1905, the contractor lost all his works, and although it was but thirty-five feet to bedrock and excavation conditions were very simple, and there was little if anything to be done to the bedrock in the river, it was not until September 20, 1906, that the first stone was laid on the Roosevelt Dam. The celebration announcing its completion occurred in March, 1911, at which time, President Roosevelt gave the dedication address.

The building of this great storage reservoir, of the Granite Reef diversion dam above Phoenix, and the rehabilitation of the old canals and their enlargement and the construction of new canals in the valley, speedily transformed the Salt River Valley. In 1904–05 Phoenix was a small town of five or six thousand inhabitants, with unpaved streets, and in a generally dilapidated and run-down condition. The farmers over the whole valley were somewhat discouraged; for, as I have explained, water conditions were extremely bad. No diversion dam existed in the river but such as would go out with every flood, so that as one old settler said at the dedication of Granite Reef Dam, "Whenever there was no water in the river we had good dams, but whenever there was plenty of water coming down the river the water washed away our structures and we had no means of diversion," so that it was frequently a question of when they were worse off.

After the completion of Granite Reef Dam, whenever there was water in the river it could be diverted into the canals, and after Roosevelt Dam was fairly well along, so that the lowest gap was some hundred feet or more above the floor of the stream, there was no further trouble with the water supply, and the Salt River Valley has changed its assessed valuation from somewhere in the neighbourhood of fourteen million dollars to about eighty million dollars in about eight or nine years. This alone speaks volumes as to the value of irrigation in a country like the Salt River Valley.

Merely to enumerate the varied crops that will grow in this highly favoured valley would be to fill up pages of this book. Suffice it to say that everything that will grow anywhere else in the United States can be grown here, with preference for the semi-tropical crops, such as grape-fruit, oranges, lemons, Egyptian cotton and the like. In this year, 1917, the Goodyear Rubber Company, who have thoroughly investigated the growth of Egyptian cotton, have purchased or leased 21,000 acres, which they are now planting to this one crop alone. An even better variety of cotton, however, than the Egyptian, has been developed in the Salt River Valley, known as the Pima Cotton, and this is the variety the Goodyears are planting.

Last year's (1916) crop report showed 47,349 dairy cattle; 23,964 beef cattle; 125,000 sheep; 71,500 hogs; 299,600 fowls; 1,600 ostriches; 9,640 hives of bees. Eighty-one thousand acres of alfalfa produced 326,000 tons; thirteen thousand acres of barley produced 332,000 bushels. There is also a splendid market for dairy and beef cattle, these latter being pastured on the mountain ranges and fattened on the valley fields. In 1917 nearly double the number of dairy cattle are daily being milked.

The chief city of the Salt River Valley is Phoenix, which is one of the most rapidly growing cities of the West. It now has a population of about 24,000 and is becoming a truly cosmopolitan and rarely beautiful city. Its winter climate is making it world-famed and its suburban localities, like Ingleside, have attracted such world-travellers as Sir Gilbert Parker, the distinguished statesman and novelist, who comes here for recuperation every winter. At Chandler, one of the new towns that have recently sprung up in the Salt River Valley, with a present population of 600, the already-famous San Marcos Hotel has been erected, which has in three seasons become to Arizona what the Glenwood Mission Inn is to California. Though increasingly enlarged each year it is yet found to be crowded as soon as each winter season opens. Other towns in the Valley, with their populations, are Mesa, 3,000; Glendale, 1,200; Tempe, 2,000; Peoria, 300; Gilbert, 50; Scottsdale, 30.

These are but straws that point out the path of continued progress in the future. Those who regard

Arizona as a mere state of wild pioneers and wilder cowboys will soon be compelled to revise their ignorance. They have not considered the civilizing effect of the Salt River Project of the United States Reclamation Service.

The project was opened by order of the Secretary of the Interior on January 18, 1917, it being understood that the first payment was to be made December 1st of this year. The cost of the project in the opening notice was fixed at $60 an acre, to be paid in twenty annual payments without interest, $1.20 per acre each year for the first four years, $2.40 per acre for the next two years, then $3.60 per acre each year for the next fourteen years.

The Water Users' Association is now negotiating a contract and it is expected that the project will be turned over to them. This, however, will have to be accomplished through a vote of the Water Users' Association. There is no government land subject to location on the project. Any prospective settler coming here must purchase land from its owner. Prices range from $100 per acre up.

The cost of water in the past has been $1 for the first two acre-feet per acre; 60¢ per acre-foot for the third acre-foot, and 75¢ for each acre-foot over the third. In 1917 on account of the heavy expenditures caused by the floods, the price of the first acre-foot has been increased to $1 with a charge of 60¢ per acre-foot for the second and third acre-feet per acre, and 75¢ for all over that amount. It is not probable, however, that this charge will be in force more than this one year. The engineer-manager has been paying a good deal of attention to the power possibilities, and points with some little pride to the success of the system, as it is very interesting to see an irrigating project pay its own way by the power development as a sort of by-product.

A brief sketch of what has been accomplished in this department will fittingly bring this chapter to a close. Of the approximately ten and a half million dollars expended on the Salt River Project, three and a half millions went to pay for the hydro-electric power-system. That is of the $60 per acre charged the settler for construction, $20 was spent on the power-system in the expectation that speedily it would become a dividend-paying proposition. This system as now developed consists of plants at Roosevelt Dam, the Arizona Canal Drop, South and Main Consolidated Canals Drop, and Tempe Canal Drop. These plants are connected by a permanent 45,000-volt transmission line strung on steel towers set in concrete footings, all the construction being of the most up-to-date character. There are six substations, Phoenix, Glendale, Sacaton Indian Reservation, Chandler, Mesa and Miami.

This power-system was primarily intended to give power for the construction of Roosevelt Dam, but when this work was completed it was found there was a growing demand for electric power throughout the Salt River Valley and cities approximately near to the Dam. The stations named are each now using this power, and from December 1, 1915, to April 30, 1917, the plants showed an earning capacity, above cost of operation, of $313,372.08. In addition to this the Service used for pumping power to the extent of $15,173.99, and charged off as "cost" for depreciation $116,521.08. Hence it will be seen how profitable this power-system will be to the Water Users' Association when it comes into full possession of it, and the clear indication of the tremendous benefits that are accruing to the people themselves from the construction and operation of these great and beneficial public works.

The present Project Manager is William S. Cone, with office at Phoenix, Arizona.

CHAPTER VII

IN THE VALLEY OF THE AMERICAN NILE. THE YUMA PROJECT, ARIZONA-CALIFORNIA

The Colorado River has always suggested the Nile, and the Mohave, Colorado, Arizona and Sonora Deserts that it crosses are near enough like Egypt to suggest it in everything save its pyramids, sphynx, ancient ruins, and modern fellaheen. The fertility of the soil in the one valley is matched by that of the other; and now that modern irrigation methods are conducted on a large scale, the dam of Assouan is matched by that of Laguna. Date palms wave over fields of cotton, alfalfa, wheat, barley, milo-maize, Egyptian corn, chili and a score of other grains and vegetables, while the same pure blue sky and insistent sun overarch the scene during the day and the rich velvety pall of bluish black, studded with brilliantly scintillant stars, covers it during the night.

While the Colorado River in the earlier years of American occupancy was called the Red River of the West, and from Spanish days was supposed to be navigable, it was soon found that its usefulness in that department of state and national life was more imaginative than real. Lieutenant Ives graphically recorded his struggles to ascend it in his small stern-wheeler, and his discovery of the canyons through which it flowed ere it entered the desert. So romantic and *different* is the Colorado that F. S. Dellenbaugh has published a fascinating volume entitled

The Romance of the Colorado River, devoted to its history.

In her *Vanished Arizona* Mrs. Summerhayes gives a vivid picture of the trip she took up the Colorado when she went to join her husband, who was ordered to one of the military posts of Arizona. The brown, sluggish flood, the wide expanse of desert on either side, the heat, the slowly progressing vessel, the sand-bars are all brought clearly before the reader, and, on reflection, the conclusion arises that *the Colorado River is not a river of commerce;* it is not a natural navigable channel for the ships of trade. While stern-wheelers of small craft *can* go up the river from the Gulf of California as far as the mouth of Black Canyon when the conditions are favourable, fifty years of experience and knowledge have demonstrated that it is far less a river of transportation today than it was in the beginning. Hence it was a great, and today it is a source of deep regret, that the United States, in its convention with Mexico, upon the fixing of the boundary line between the two countries, affirmed that it was a navigable stream. This affirmation has stood in the way of the full utilization of the waters of the river for purposes of irrigation, evidently the chief usefulness, at the present, anyhow, it may attain.

Long ago Major J. W. Powell realized this as a fact, and he foresaw the diversion of the almost useless waters of the river upon the rich soil on either side of its lower course. Above this lower stretch its banks rise to the towering walls of canyons, culminating in that natural phenomenon of majestic scenery known as the Grand Canyon of the Colorado

—the most stupendous abyss of rock known to man. Hence, when the Reclamation Act was passed, one of the first rivers to be thoroughly and intelligently studied was the Colorado, with a view to the utilization of its waters upon the near-by desert lands.

The Colorado, however, presented so many problems, difficult of solution, that it was not easy to determine where the diversion dam needed should be located, or to fix upon the type of dam which should be constructed. Two or three sites were proposed, and systematically studied from the engineering standpoint before the site of the present dam was determined upon. Another difficulty was found to exist, that the normal low-water supply of the Colorado River was insufficient for the satisfactory irrigation of the large areas contemplated, and this could be remedied only by the creation of large storage reservoirs in the drainage areas of the Grand and Green River systems, these rivers forming the Colorado. It was finally decided, however, that there was a sufficiency of water for the irrigation of the Yuma lands, and after the making of the preliminary surveys, the Secretary of the Interior, May 10, 1904, authorized the construction of the dam at Laguna, ten miles northeast of Yuma.

It was originally contemplated that the main diversion would be on the Arizona side; the water would be carried down toward the Yuma Valley on that side of the river, siphoned under the Gila and passed through a tunnel under the mesa back of the town of Yuma. Further study made evident many difficulties in this route, and after more study and a number of estimates made, the canal was finally located on the California side and carried under the Colorado River in a siphon at Yuma immediately below where the railroad bridge crosses the Colorado River. In addition to serving land on the California side, in the old Indian reservation, this water also serves lands on the Arizona side below Yuma in the lower Yuma Valley, and it is planned that, ere long, it will also be pumped up, from 80 to 100 feet, to the mesa lands south of Yuma, where from forty to seventy thousand acres of excellent citrus fruit lands will be reclaimed. The oranges and grape-fruit grown hitherto on these lands are of the finest quality, and while the pumping will be expensive, the value of the lands will more than justify the expenditure.

The lands adjacent to the Colorado River are protected from overflow during flood times by means of dikes.

The board of engineers, which approved the plans for the project, consisted of Messrs. A. P. Davis, present Director and Chief Engineer; G. Y. Wisner, J. H. Quinton, W. H. Sander, B. M. Hall, and H. N. Savage. The preliminary surveys were directed by Mr. J. B. Lippincott from the mouth of the canyon where the Colorado River emerges to the Mexican boundary. He finally selected this site, as it promised most, everything being considered, though another project, to be located near Parker, which would have irrigated 100,000 acres, was seriously considered. At that time, however, there was no railway at Parker, and this is essential not only for purposes of construction but also to provide a means of marketing the products of the project.

There being no bed rock in the Colorado River at this, or any other available location, it was decided to construct an overflow weir of the Indian type. This is built on the quicksands of the river, anchored in solid rock on each side. Its dimensions are, roughly, length 4,780 feet, maximum width 250 feet, height fifteen to nineteen feet except in centre, which is forty feet, composed of a rock-fill between two parallel walls of concrete extending entirely across the stream between the natural rock abutments on each bank. The top of the rock-fill and the down-stream surface of the dam are sheeted with a concrete pavement eighteen inches thick.

The backwaters above the dam form a lake ten miles in length and of varying width. The water of the Colorado River sometimes bears three per cent. of silt, and when used direct from the stream upon agricultural lands produces a "silt blanket," detrimental to the best crop results. The problem that science was called upon to solve through the medium of modern engineering was to eliminate a part of this silt deposit and still allow sufficient percentage of it to be carried down to the farms to insure constant natural fertilization of the soil. This has been accomplished by means of concrete sluiceways at both ends of the dam, one in Arizona and the other in California. These sluiceways are 1,000 feet in length and so graduated in dimension that the water that passes through them maintains a velocity of about sixty feet to the minute, allowing the proper proportion of silt to form sediment in the bottom. It is flushed off periodically, through openings constructed for the purpose, into the river below the dam.

The two sluiceways form the communicating link between the lake above the dam and canal system. At their respective outlets are "controllers" allowing the water to flow as wanted into the canals. The controllers are so arranged that the top water only flows over, retaining the silt behind the gates to be sluiced into the river as described. The soluble fertilizer carried in the water is not impaired and only the proper proportion of silt goes with it.

It is interesting to note that the United States Geological Survey *Water Supply Paper 274* reports that 338,000,000 tons of mud and silt, as suspended matter, together with 4,550,000 tons of sodium chloride, or common salt, 3,740,000 tons of Glauber's salts, 4,000,000 tons of lime, 2,400,000 tons of gypsum, and 4,800,000 tons of Epsom salts, are *annually* carried by the Colorado River and deposited in the Gulf of California.

Ever since the gold rush to California in 1849 Yuma has been well known. It was near here that the Spaniards, over a century before, established two Franciscan Missions for the Indians, both of which ended disastrously. The Indians rebelled against religious control and the exactions of the Spanish soldiers, slew the friars and other hated foreigners, and destroyed the Missions. This same spirit was shown when the American gold-seekers and pioneers came into the land. Hence a fort was established, on the hill overlooking the Colorado River, on the California side, which, however, has long since been abandoned, and is now used as the headquarters of the Indian agency and school.

While Ehrenburg, further up the river, was the landing-place for the stern-wheelers that plied up and down from the Gulf of California, and supplies for Arizona were hauled therefrom, the coming of the Southern Pacific Railway, in 1877, created a depot for supplies for the great mining industry of the region which from now on began to develop with rapidity. But it was not until the late 'eighties and early 'nineties that agriculturists awoke to the marvellous fertility of the Colorado River valleys, and when they did, there were not enough of them to combat the mighty power of the turbulent and uncontrolled Colorado in flood times. For, with its vast watershed of 242,000 square miles, including the headwaters of the Grand and Green rivers in Wyoming, Utah and Colorado, which reach up into the high mountain ranges, where the snow falls deep and long, it pours down incredible volumes of water when the springtime opens up the floodgates. The puny attempts of the earlier settlers at damming the river and building controlling levees were pathetic in their inadequacy.

Yet the land allured and beckoned with a fervour that many could not resist. And the years to come, when all the beneficent work of the Reclamation Service is completed, and time for development and stability has proved the wisdom of the foundation-layers, will demonstrate how far-seeing were some of these men who staked their little all of money and their prodigality of work and faith, only to see everything swept away by an unexpected flood. For we now know that this Colorado River is the Nile of America, and that there is no richer land under the sun. It has been the fashion to joke about the heat of Yuma, and there is no denying its heat—which ranges as high as 119° Fahr.—but men of wisdom are now seeing in that heat the great factor in the wonderful growth of crops in the Yuma region. With a rich and fertile soil, an abundance of water, and heat —steady, persistent high temperature—the country becomes a great forcing-house, a conservatory for the growing of fruits, vegetables, etc., that struggle to attain maturity elsewhere. Sensible men, therefore, seeking a location where they can control the growing of rare crops, gravitate toward Yuma. The Reclamation Service officially states:

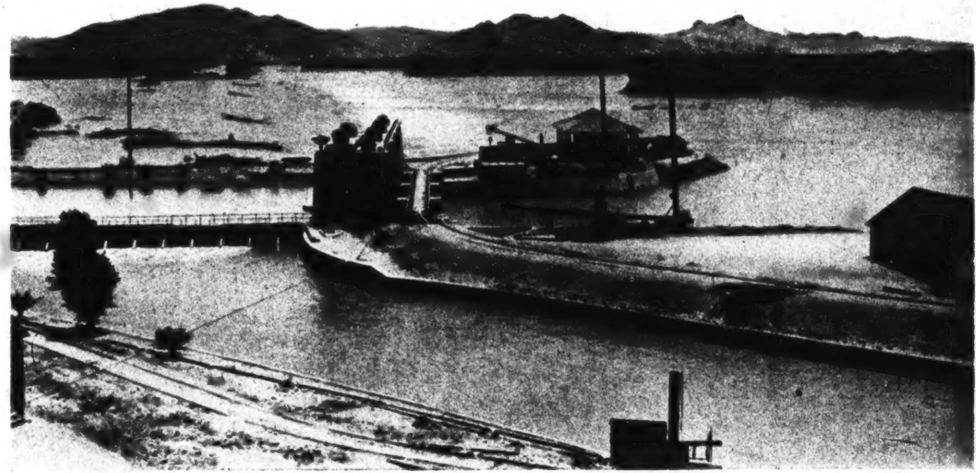
> In climate Yuma Valley is dry and semitropic, a climate productive not only of wealth but of health. While the temperature averages about seventy-three degrees, the thermometer does not give any idea of the climatic conditions because of the lack of humidity in the atmosphere. The secret of the long growing season lies in the fact that the sun shines ninety-five per cent. of the days of the year, and it is rarely cold enough to injure the most delicate plant. Flowers bloom the year around, and the frosts which occur occasionally in the early morning hours of the winter months, notably in December and January, are not severe enough to interfere with winter gardening. The rainfall averages about three inches and occurs at irregular intervals during the summer, fall and winter months. The valley is free from severe storms and tornadoes are unknown. The most severe wind-storms rarely last more than twelve hours, and during these no houses or trees are injured. Night is as comfortable as the day, and throughout the year many people sleep in houses constructed of cheesecloth stretched over frames.
>
> Nature has not only supplied the region of the Yuma Project with many of those features essential to the production and maintenance of abundant life, but has left it singularly free from destroying elements. The valley lies outside the path of the regular winds, and is therefore never

visited by severe storms. The evening winds from the Gulf of California appreciably lessen the heat of the day and make the nights pleasant.

It is also well to remember that during the last thirty-five years there have been but 145 days when the Government thermometer recorded to and below thirty-two degrees Fahrenheit, an average of four to the year, and on four of those years freezing-point was not reached. The period during which the "cold spell" lasts is from two to five hours.

Hence it will be seen that the growing season is from January first to December thirty-first, without cessation, and that the possible variety of fruit and vegetable products is unlimited. While citrus fruits do not thrive in the lower lands of the river bottom they do well on the mesa above Yuma. Indeed, though I myself am a Californian, I confess frankly that the oranges of the Yuma mesa are richer in flavour and sugar content than California grown fruit, and that in my judgment, there are no grape-fruit in the world that can compare with those grown here. I have eaten half a dozen, one after another, without sugar, so rich and delicious do they ripen in this beneficent clime. Then, too, citrus fruits ripen so early that they are in the market before Christmas, and thus bring the highest prices.

Egyptian cotton, with its long, fine, strong staple, is rapidly becoming a profitable crop. It is found to grow here as well as in its native Nile habitat, and as soon as the farmer overcomes the initial difficulties in its production, he realizes large profit from its cultivation.



LAGUNA DAM, ONE MILE LONG, ACROSS COLORADO RIVER
YUMA PROJECT, ARIZONA-CALIFORNIA

Date culture is also assured. The experimental stage is practically passed. Profitable results have been obtained at the Experimental Station, and while the bringing of date palms to maturity and bearing is rather a slow process those who can afford to plant and wait are pretty certain of satisfactory returns. Dates need great heat and an abundance of water—"feet in water and heads in the sun," say the Arabs—and the abundant supply of water now secured by the Reclamation Service, combined with the steady sunshine, provides these two needed factors in their profitable development.

Of vegetable-growth too much cannot be said. During the winter cabbage, cauliflower, beets, lettuce, radishes, onions, endive and many others thrive and they can be grown the rest of the year also. Luscious watermelons, cantaloupes, casabas, enormous tomatoes of exceptional flavour, wonderful cucumbers yield over and over during the warmer season as long as they are planted, irrigated and cultivated. Sweet corn may be planted every three weeks from February to the middle of August and will furnish roasting ears considerably more than half the year without interval.

As soon as one crop is harvested the ground is ready for another. By planting between the rows of growing corn or potatoes, for example, two crops will result from the same ground at practically the same time. Irish potatoes can be planted in January and harvested in May. Corn planted between the potato rows in March will mature by June 1st. On the same ground corn has been planted August 1st and turnips added between the rows the last of

September, all maturing. Vine products, such as pumpkins, squash and others, produce heavily. Sugar-cane, sorghum, peanuts, maize and the like are native. Milo-maize has become quite a standard stock feed and is used to some extent for human consumption. Its grain is very rich and nutritious. It turns out about four tons of threshed grain per acre.

Alfalfa is the principal hay crop, and its growth, like everything else in this section, is very rapid. A cutting of hay is not uncommon at three months from planting the seed, and it is not uncommon to secure seven, eight, nine and, in some cases, as high as ten and even twelve cuttings per year, with an average yield of from ten to twelve tons per acre. Alfalfa seed is also a profitable product, one farmer having secured as much as 1,800 pounds per acre, from four acres. Another farmer's yield on thirty-four acres was 1,200 pounds per acre.

Barley and corn may be grown on the same ground the same year, each producing fifty bushels to the acre. Barley is also grown for hay and yields from two to four tons per acre. Wheat and barley can be sown in the fall and pastured all winter, and a good crop harvested early in May. Alaska wheat does very well here. The grains are large, clean and very nutritious. All grains are free from smut or other diseases or pests in this locality.

Under such conditions it can be seen that hogs, cattle and poultry thrive. With an abundance of water and varied fodder and grains for feed they fatten readily, and being on the main line of the Southern Pacific Railway, with the Arizona mining country for market on the one side, and California with its vast tourist and regular population on the other, the profitable disposal of all products is assured. Yuma is 251 miles southeast of Los Angeles, 250 miles west of Tucson, Arizona, 197 miles southwest of Phoenix, the capital of Arizona, and 562 miles west of El Paso, Texas. It is on the Ocean-to-Ocean Highway, with that magnificent highway affording ready communication in both directions. A fine steel bridge now crosses the Colorado River, and this naturally makes Yuma a converging point for automobile travel to and from East or West. The span is over 350 feet. There are also two Howe truss bridges, one on the main canal of 110-foot span, and the other over the Reservation Drainage Canal, on the Ocean-to-Ocean Highway.

Yuma is a growing city, fairly progressive, as its appearance testifies. It has a fine high school, with excellent grammar schools and churches, public works that are a credit and modern clubs, including two women's clubs. In the schools six languages are taught. The streets are macadamised, the city has cement sidewalks, a good water system, electric lights and gas, two banks, several hotels, two daily and one weekly newspaper, some manufacturing concerns, canneries and up-to-date places of amusement.

A cursory survey of the vast engineering plant and work of the Reclamation Service reveals the secret of Yuma's development, together with that of the surrounding country, including the smaller settlements of Somerton, Gadsen, Kopa, Wendendale, Bouse, Potholes and Bard.

The Laguna Dam, though submerged, is a scene to stir one's imagination. It is 4,780 feet long, and

250 feet wide. It was a gigantic task, not financially successful to its first contractors. Consequently it had to be completed by the Reclamation Service's own engineers and workmen.

During the building of this monster structure the most severe test upon the ability of man to stop the river was experienced when the centre of the stream was reached. The sluiceways at either end were intended to carry the flow of the river during the construction period, their capacity being 16,000 second-feet. As the cofferdams were extended from either side of the river the opening in the centre became narrower and the quantity of water forced through the sluiceways, constantly increased. When matters were in this critical shape word was received from the man on lookout duty up stream that a flood was on its way down and would reach the dam in a few hours. Every man on the work knew that the battle was on from that moment. The force was increased to 600 men and trainload after trainload of quarry stone was dumped into the opening. All through the night the men toiled, under electric light, not knowing at what moment the cofferdam might give away under the weight of the rising flood. From the supervising engineer, L. C. Hill, down to the foremen every man was in his place on the line of battle, and by taking advantage at every point, the dam was kept above the torrent, and the victory over the Colorado was won.

The great concrete structures for diverting the flow of water on either side of the river are impressive and satisfying, and equally so as one drives along the canals and laterals, and over the substantial concrete bridges, getting glimpses all the way along of the 235 wooden structures of various types, comprising farm-unit water gates, lateral checks, and turnouts, culverts, bridges, drops, etc.

The great siphon, for the conveyance of 1,400 second-feet of water, was built under the oversight of Francis L. Sellew, the project engineer. This embraced concrete caissons for two shafts, connected by a concrete tube under the river, having a diameter of fourteen feet. The tunnel was driven from the Arizona side, the men working under compressed air, which was necessary to prevent seepage from above. The depth of the shaft is 80 feet on both the California and Arizona sides, the concrete tunnel being 950 feet in length. The up-stream end of the siphon is controlled by a cylinder gate protected by a screen to keep large floating objects from entering. The gate is 14 feet in diameter.

The tower above the siphon on the California side is a handsome concrete structure, surmounted by an American eagle done in solid brass.

The Reclamation Service, in order to further its construction work, built a railway on the levee on the California side, thirteen miles in length, from Yuma to Potholes—as the station at Laguna Dam is called. It is now operated by the Southern Pacific Company. The Reclamation Service also constructed a railway upon its levee on the Arizona side reaching down from Yuma to the Mexican line. This comprises about 25¾ miles and it is operated for the convenience of the settlers of the Yuma Valley, as well as for the necessary protection of the levees from flood.

The irrigable area of the Yuma Project comprises some 128,000 acres, divided into separate units, as follows: Yuma Indian Reservation, 15,000 acres, of which 6,500 acres were opened to white settlers under public notice in 1910, the balance being divided among the Indians in 10-acre plats; Yuma Valley, 55,000 acres; Gila Valley, 18,000 acres, 8,000 of which are on the north side of the Gila River; and the mesa land, 40,000 acres.

The Service is now ready to supply water to 60,000 acres. In June, 1917, 36,000 acres were actually irrigated, and the area is now increasing at the rate of about 500 acres per month. Irrigation is carried on every day in the year, and the elevation of the irrigable area varies from 100 to 300 feet above sea-level. The average annual rainfall for sixteen years is 3.62 inches.

The farm unit for land in private ownership on the Yuma Project is 160 acres, but where land is taken up under the Homestead Act, the unit is 40 acres.

At present there are no public lands available for entry in the Yuma Valley, or the Indian Reservation on the California side of the Colorado River. The irrigation of the Yuma Mesa, where the lands are considered to be adapted principally to citrus and other fruits, is provided for by a recent Act of Congress whereby the public lands are to be sold and the money so raised used in the construction of the necessary pumping plants and distributing system. The Reclamation Service is now working out the plans for this project, but the date of the sale of the lands and the time when water will be available for their irrigation are still indefinite. Provision is also made to take in what private lands lie within the areas of the proposed pumping units.

Privately owned lands in the Yuma Valley may be purchased, and information as to terms and prices can be obtained from the Yuma County Commercial Club at Yuma, Arizona, who will also supply names of dealers. Seventy-five dollars an acre is about the minimum price for which uncultivated lands can be had, and at this figure the location would necessarily be some distance down the valley from the town of Yuma. For lands near the town much higher prices prevail, rising with improvements and location. It is estimated that the average expenditure will not run much under seventy-five dollars per acre for getting raw land into alfalfa. This would include clearing, levelling, bordering, and planting. Other classes of cultivation will vary in accordance with the crop desired, running from pasture to orchards, and the "personal factor" of the rancher will always enter largely into the cost.

A "Warrenite" (macadam and asphalt) highway has been completed from the town of Yuma down to Somerton, fifteen miles below, and this, with what service can be supplied by the Yuma Valley (Government-owned) Railroad down the levee on the west side of the valley, should not be overlooked when considering the cost of hauling products to Yuma. Cars coming up on the Yuma Valley Railroad can be switched directly onto the main line of the Southern Pacific for carrying to their final destination, and a great deal of hauling by motor truck on the Somerton highway is now facilitating transportation.

The cost which the rancher must repay for Government construction in the Yuma Valley unit was recently announced as $75 per acre. The cost for water is 75 cents per acre-foot (1 acre covered to a depth of 1 foot) and about 5 acre-feet per year will be used to each acre of land. In making the construction payments a period of twenty years may be taken, or the farmer may pay up sooner if he so desires. These figures may appear to be high to one not initiated into the practice of irrigation, but when it is borne in mind that from five to seven cuttings of alfalfa hay may be taken from the land during one year, and that great concentration in the raising of all other crops in like proportion may be carried on for three hundred and sixty-five days in the year, the per-acre charge ought to fade away on its side of the ledger if the landowner combines good farm management with plenty of hard work. Besides this, the long period of twenty years that may be consumed in paying up the charge is carried by the United States Government without any burden of interest; or, to look at it from the banker's view-point, the Government allows the farmer to pay back interest at an average rate of only five per cent. a year for twenty years, and then makes him a present of the principal.

The present Project Manager is W. W. Schlecht, with office at Yuma, Arizona.

CHAPTER VIII

GROWING ORANGES UNDER THE SHADOW OF MT. SHASTA. THE ORLAND PROJECT, CALIFORNIA

California has been known ever since the days of gold as the state of romance. Romantic in its Spanish Missions, when the Franciscan friars planted the olive, the vine, and the orange; in its wonderful gold rush, which made it the mecca of thousands of gold-seekers from almost every country under the sun; in its cowboy epoch, when cattle were its dominant industry; in its agricultural and horticultural development, when it was found that, given water, its soil was productive beyond the ordinary thoughts of ordinary men; in its alluring attractiveness to the tourist pleasure-lover, and health-seeker; in its mountains, lakes, canyon-valleys like the Yosemite, seaside resorts, and islands; in its hunting, fishing and other sports; in its outdoor recreations; in its exquisite flower displays and the glory they confer upon its homes—these, and a score of other features, have added to the romantic reputation of California throughout the world.

In its rise into prominence as a place of fruit culture certain far-seeing men of later days took note of the fact that the orange, planted by the Mission Fathers, in certain parts of the state, seemed to have thriven abundantly. They began to experiment with it, therefore, as a horticultural possibility. Well do I remember—one of the first things I ever saw in San

Francisco—the unloading of a vessel at one of the wharves there, possibly from Hawaii, the chief burden of which was oranges. Many of the boxes were opened on the wharf and sorted, the rotten fruit being thrown aside. To my surprise certain men took the seeds from these rotten oranges, washed and then sacked them with the evident intent of using them. Afterwards I learned that they were sent to Riverside—which had been established a few years earlier—and there planted, thus beginning the growing of seedling oranges for the markets of California.

Then by a fortuitous concomitance of circumstances a Riverside orange-grower received six navel-orange trees that had come to the Agricultural Department, at Washington, from Bahia, Brazil. From these six trees sprang the Riverside Washington navel-orange industry, there now being millions of trees of this variety in California and Arizona, all of which are descended from these original six trees. Two of these, by the way, are still in existence, in Riverside.

Oranges thus became recognized as a regular crop of the southern part of the state of California, and soon lemons and grape-fruit were added to the list. But it was early discovered that citrus fruits could not endure much frost, hence it was deemed that the only region in which they could successfully be grown, without risk from frost, was south of the Tehachapi range, and even there only in certain "thermal belts."

This supposedly natural allotment for the sphere of citrus culture was accepted as final by the majority of people, but, thank God, there are always a few minds who refuse to accept popular conclusions, and who question, test, experiment. Some of these tried the planting of oranges and lemons in the foothills of the southern end of the San Joaquin Valley. Others, a little later, were tempted to test them further north, and in most cases with success. A few more daring ones were satisfied that a thermal belt, where frost was unknown, existed in the upper end of the Sacramento Valley, and they planted orange groves there, which, to the surprise of those who did not know the climatic facts, thrived abundantly and brought good profit to their owners.

Then there came a few seasons of destructive frost in Southern California. Citrus orchards lost millions of pounds of fruit, and although there were comparatively few trees that were ruined, many growers lost so much fruit that their incomes were seriously impaired. By this time the tests in the Sacramento Valley had proved so successful that one grower sold out his Riverside groves, and began the planting out of five thousand acres of oranges, grapefruit and lemons in the foothills of the Sacramento Valley.

A few years prior to this time the Reclamation Service had determined to establish an irrigation project in California. The choice of location fell upon the upper portion of the Sacramento Valley—as its lands are semi-arid—in Glenn County, near to the town of Orland. This used to be the centre of one of the greatest grain-growing areas in California, heavy crops of wheat and barley being produced annually, the rainfall occurring mainly in the winter months, and averaging about seventeen inches per year. But in due time the soil became exhausted through the growing of a single crop, until grain-growing was no longer profitable, and the farmers' attention perforce was turned in some other direction.

In the early days of American occupancy the whole of this region used to be owned by a few men who refused to part with any portion of their holdings. A better day, however, finally dawned, either when these men died, or were blessed by a change of heart, and the large ranches began to be subdivided and sold at reasonable prices, so that men of ordinary means might come in and establish farms and homes here.

The necessity for irrigation was realized as far back as the '80s and an irrigation district was formed under the State law, but no work was done, because of inability to finance the undertaking. Later the Stony Creek Irrigation Company was incorporated, dug a few miles of canal and irrigated, through a portion of each summer, about 150 acres of land in and around the town of Orland. Also the Lemon Home Water, Power and Light Company, which had laid out a colony near the Tehama County line, built a short canal for the purpose of irrigating the lands of the expected colonists, and those of one or two of the old residents in the section traversed by the Company's ditch. The colonists, however, did not materialize and the irrigation service of both companies was only partial, lasting through the early summer only and failing at midsummer when the heat and the need of water were greatest.

The source of water supply is Stony Creek, a very considerable tributary of the Sacramento River, and one of the largest streams emptying into the Sacramento from the west side of the valley. It discharges a large volume of water during the season of its greatest flow and at times is a raging torrent, but it dwindles rapidly as soon as the rains cease and by July 1st is usually entirely dry at Orland.

The U. S. Geological Survey had located several reservoir sites along Stony Creek and its tributaries but the people were too poor, too sceptical, and too discouraged to make use of them and, at that time, private capital had steadfastly declined to see opportunities for profitable investment in the Sacramento Valley. Under these circumstances a few of the people in the vicinity of Orland, with the assistance of the Sacramento Valley Development Association, took action looking toward the construction of a Government project under the Reclamation Act.

In the year 1905 the owners of 40,000 acres of land signed an agreement to accept and be bound by the terms of the Reclamation Act and to sell off their holdings in excess of 160 acres in tracts of not to exceed forty acres, and in February, 1906, a Water Users' Association was formed and duly incorporated and presented a petition to the Secretary of the Interior, reciting the facts regarding the fertility of the soil, the favourable climatic conditions, and the advantages offered to settlers, and asking that the surveys along Stony Creek be completed and for the early construction of an irrigation project in the vicinity of Orland.

A surveying party and diamond drill outfit were put into the field in July, 1906, and continued at work until the following November.

In November, 1906, a board of engineers recommended the construction of the Orland project under certain conditions, and the Orland Unit Water Users' Association at once reorganized to meet the new conditions.

To provide the required storage the reservoir site at East Park in Colusa County, California, was selected and designs were prepared for a concrete dam 90 feet in height above stream bed on Little Stony Creek at a point about three miles above its confluence with the main stream, to impound 46,000 acre-feet of water for use after the failure of the natural flow of Stony Creek in the midsummer of each. The water, when discharged from the reservoir, was to follow the bed of Little Stony and Stony Creeks to Miller Buttes, a distance of 41 miles, and to be diverted at the point where the creek breaks through the foothills and begins its flow southeastwardly through the valley toward the Sacramento River, the diversion to be accomplished by a low concrete dam at Miller Buttes into the South Canal whence it is distributed to that part of the project lying south of Stony Creek. A diverting weir for the North Canal was also contemplated but its location was not fixed at this time.

Meantime an office had been established at Orland and Mr. T. H. Humphreys was placed in charge as Project Engineer. The work of securing the lands necessary for the reservoir was pushed actively (valuable aid being rendered by the officers of the Water Users' Association) and about 4,000 acres were purchased.

In the spring of 1909 work was begun on the East

Park Dam, and with the exception of one or two brief interruptions on account of high water, it continued until it was completed June 15, 1910. This dam is located in a gorge of conglomerate, is built of concrete and is on a radius of 275 feet. It is 139 feet high above foundation and has a top length of 250 feet. It is ten feet thick at the top, and 86 feet at the base. Twenty feet above the bed of the river is a circular conduit which constitutes the main outlet. This is controlled by two sluice-gates each 4x5 feet, set in tandem, seven feet apart on opposite sides of a gate tower. Originally the dam had a storage capacity of 46,000 acre-feet, but it is now increased to 51,000 acre-feet.

The spillway is located in a saddle about a quarter of a mile from the dam. It is a concrete structure founded on hard shale. It is a weir consisting of nine semi-circular arches resting against piers eight feet wide. The arches have a radius of 13½ feet, and the whole structure is curved to a radius of 474 feet, its total length being 415 feet. It is designed for a capacity of 10,000 cubic feet per second, with a depth of overflow of 3.7 feet. A water cushion is formed by a series of small weirs two feet high on radii of 29 feet, built down-stream from the main weir.

The acreage included in the project which it was supposed could readily be irrigated from the dam amounted to 14,300 acres. But for two successive seasons after the project was opened, the run-off into the reservoir fell far short of the capacity—in one year to about one-fourth, and the next to a little over one-third. Something must be done, and done instantly, to provide against the disaster of water shortage. Fortunately all the acreage was not calling for water. It was decided to build a feed canal from Big Stony Creek to the reservoir, a distance of seven miles, and to increase the storage capacity by 5,000 acre-feet, by building the spillway three feet higher. These improvements were carried out in 1914.

The diversion dam for this feed canal is a concrete arch built to a radius of 100 feet, with a crest length of 154 feet, and a maximum height of 44 feet. Its greatest thickness is six and one-half feet, and this diminishes to three and one-half feet near the top. The crest of the dam is curved down-stream in vertical section, in order that the overflow may fall free from the dam and cause no vacuum.

The system contemplates the delivery of water directly to every 40-acre unit through 138 miles of Government canals and laterals, and when completed will contain 2,000 concrete control structures of varions kinds.

Beginning in October, 1909, the South Main Canal (the old Stony Creek Irrigation Company's ditch) was rebuilt from Hambright Creek, some five miles northwest of the town of Orland, to its terminus on the northern boundary of the town, 31 reinforced concrete drops were constructed and the necessary bridges and siphons to carry the canal under the country road at the two or three points of crossing were built.

The first Government irrigation was in the season of 1910, in which year water was furnished to 500 acres of land mostly in and contiguous to the town of

DIVERSION DAM AND DITCH
ORLAND PROJECT, CALIFORNIA

EAST PARK DAM, DOWNSTREAM FACE—HEIGHT 127 FEET,
LENGTH OF CREST 220 FEET
ORLAND PROJECT, CALIFORNIA

Orland and largely land which had formerly been served by the old company ditches. As the East Park dam was not finished until June there was no stored water available and irrigation was continued only until the natural flow of Stony Creek failed, which was during the month of July.

The beginning of irrigation in 1911 was delayed about two weeks by a flood following a torrential rain on March 5th. The creeks were out of their banks and, for a time, a large volume of Hambright Creek was pouring into the South Canal and overflowing into the county road and over the contiguous property. The South Canal, designed to carry a maximum of 150 second-feet, was receiving from Hambright Creek about 260 second-feet for several hours and it stood the strain successfully, both in its banks and structures, little damage being done. At the headworks the flood had piled up the gravel in the sluiceway and before the gates and had entirely filled the channel on the south side of Stony Creek so it became necessary to clear away the deposits before the gates and excavate a channel to bring the water over the intake.

The South Main Canal, as it was purchased from the Stony Creek Irrigation Company, descended nearly 35 feet in the three miles above the Hambright Creek crossing, a fall which would produce too high velocity for the amount of water necessary to irrigate the project. This necessitated rebuilding the canal and the construction of a number of very expensive concrete structures would have been necessary to reduce the velocity. As an alternative it was decided to build a new canal along a higher level

—a canal that would require no drops whatever and would, besides, provide a power site at its lower end should a power plant become desirable. A line was located along the hillside, the right of way secured at a cost of $1,350, and advertisement inviting proposals for its construction issued on August 1, 1910.

In due time this was completed and is now in successful operation. At the outlet of this canal there is available for future hydro-electric development not less than 450 horse-power. As the city of Orland grows this power will undoubtedly be called for.

Before the authorization of the Orland Project the land was worth comparatively little. In favourable seasons a small crop of grain could be grown on a part of what is now included in the project limits, but for the most part the fields lay idle. The country was sparsely settled, only an occasional ranch house surrounded by a small grove of trees breaking the monotony of the level plain—a thirsty land crying for water to make it fertile. The town of Orland was a collection of more or less dilapidated wooden stores which, leaning against one another for support, expressed the discouragement felt by the people. The short irrigation season afforded by the old companies which supplied but about 150 acres had done little more than demonstrate what might be accomplished with a full season and plenty of water. As soon as the project was assured, things began to move; prospective settlers began to make inquiries, the price of land went up with a bound from $15 and $20 per acre to $50, $60, $75, and in the course of three years to $125 and $150. The real estate men were kept busy selling farms to the people who came in, land was levelled, houses were built, and a general air of prosperity prevailed.

In the town, where the improvement was first shown, the changes were extraordinary. In one year (1909–10) $100,000 was invested in new business buildings; most of the old unpainted ramshackle buildings were torn down and replaced by modern structures of concrete and the business part of the town, six years after the beginning of active work on the project, presents blocks of well built reinforced concrete buildings with modern plate glass fronts quite in metropolitan style. More than two hundred new residences have been built, mostly of the attractive bungalow type, and the town, though somewhat scattered, has taken on a "smart" aspect unusual in new communities.

In the country the development has been none the less marked. New cottages have sprung up in all directions and large barns have been built to shelter the horses and dairy cattle which have been brought in; fields of alfalfa show vividly green where formerly the yellow burned-up native vegetation held full sway, and young orange, almond and other fruit trees are flourishing; the lowing of cattle and the cackling of hens have taken the place of the erstwhile silence and the voice of chanticleer is heard in the land. The value of improvements on irrigated lands in 1910 was $25,000. Today the valuation conservatively is estimated at $875,000.

The project was opened by public notice on the 24th of May, 1916. It now contains over 20,000 acres of irrigable land, about 14,000 acres of which are now

(1917) under irrigation. Over 600 applications for water right have been received up to date, covering 17,000 acres.

In the last eight or ten months fully a hundred new settlers have been added, most of whom are developing their holdings. The dairy business has increased in a remarkable manner. In 1911 there were perhaps 125 head of indifferent milk cows to be found. Today there are more than 4,000, and 70 per cent. are of graded and pedigreed stock. There are two creameries in active operation, which are paying out about $45,000 a month for butter fat, and this means prosperity for the farmers. In addition the orange industry has thriven beyond all expectations. In 1916 *twelve car-loads* were shipped east, these being the first carload shipments ever effected, and as other orchards come into bearing the output will materially increase. And, as has elsewhere been shown, these oranges ripening so early, reach the eastern markets ahead of those shipped from other parts of California, and win the heaviest prices.

While unimproved land valuations have scarcely increased since 1913, viz., $100 to $150 per acre, there has been a very beneficial change in the method of placing them in the hands of settlers. Instead of requiring a payment of half or more down, as was done in earlier days, a payment of ten or twenty-five per cent. is expected, with no other payments for three to five years, except taxes and interest. Then the balance may be paid in four or five more years. In this way the settler is given full opportunity to get fairly well established before full payment for his land is exacted. The building cost of the project has been fixed at $44 per acre, with the twenty year period for paying it in.

As a result of these favourable conditions the town of Orland has rapidly grown. From a population of about 600 in 1910, it now (1917) has fully 3,500.

On the occasion of the opening of the project it was my pleasure to give the main address. By an unfortunate concomitance of circumstances the representative of Congress, the Governor of the State, and the district engineer were all prevented from being present, and by an equally peculiar but fortuitous concomitance, they each invited me to act in their stead. So I had the weighty responsibilities and honours of Congress, the Governorship, and scientific engineering to uphold, not only in the address that was delivered to a great throng that had assembled from all the surrounding country, but in observing what the Service had accomplished for the benefit of the region. Perhaps it was to this combined weight of responsibility that I owe my ever-growing reverence and respect for the helpful work the Service is accomplishing. For ever since those days spent in studying the Orland Project I have been more eager than ever to see all the other projects, and as I have studied them in their wonderfully varied detail my respect and reverence for those who have created them, as well as my pride and patriotism, have grown.

The present Project Manager is A. N. Burch, with offices at Orland, California.

CHAPTER IX

WHERE INDIANS ONCE ROAMED. THE GRAND VALLEY PROJECT, COLORADO

The irrigation plan of the Grand Valley Project provides for the diversion of water from the Grand River by a dam about eight miles northeast of Palisade, Colorado, into a canal system on the north side of the river, for the irrigation of lands lying north and west of Grand Junction, Fruita, and Mack, Colorado. About 42,750 acres will be supplied by gravity and 10,250 by pumping plants to be located along the main canal.

The Grand River has its source among the high peaks of the Front Range in the north central part of Colorado. Flowing in a generally southwesterly direction through Middle Park, it enters the Gore Canyon near Kremmling and from here to Palisade is confined between canyon walls for the greater part of its length. At Palisade the canyon walls recede and the river enters the Grand Valley where is presented the only opportunity along the entire course of the river for extensive diversion of its water for irrigation. Flowing through the valley for a distance of 30 miles, it again enters a canyon, continuing its course to its intersection with the Green River in Utah. From Palisade, to a point near Cisco, Utah, the valley is about 100 miles in length and varies from two to twelve miles in width. Just east of the Colorado-Utah line, the valley is divided by a high ridge traversing it from north to south, known as the Excelsior Divide. For a long time it was considered that it might be feasible to carry water through this ridge by means of a tunnel or deep cut to water the Utah lands, but investigation showed the land on the Utah side to be 200 feet higher than that on the Colorado side, and that the Utah lands could not be reached without pumping.

The Grand Valley Project, therefore, was planned to include only those lands in the State of Colorado lying east of the Excelsior Divide, and the term Grand Valley includes that part of the valley between the mouth of the canyon at Palisade and the Excelsior Divide, about three miles east of the Utah line.

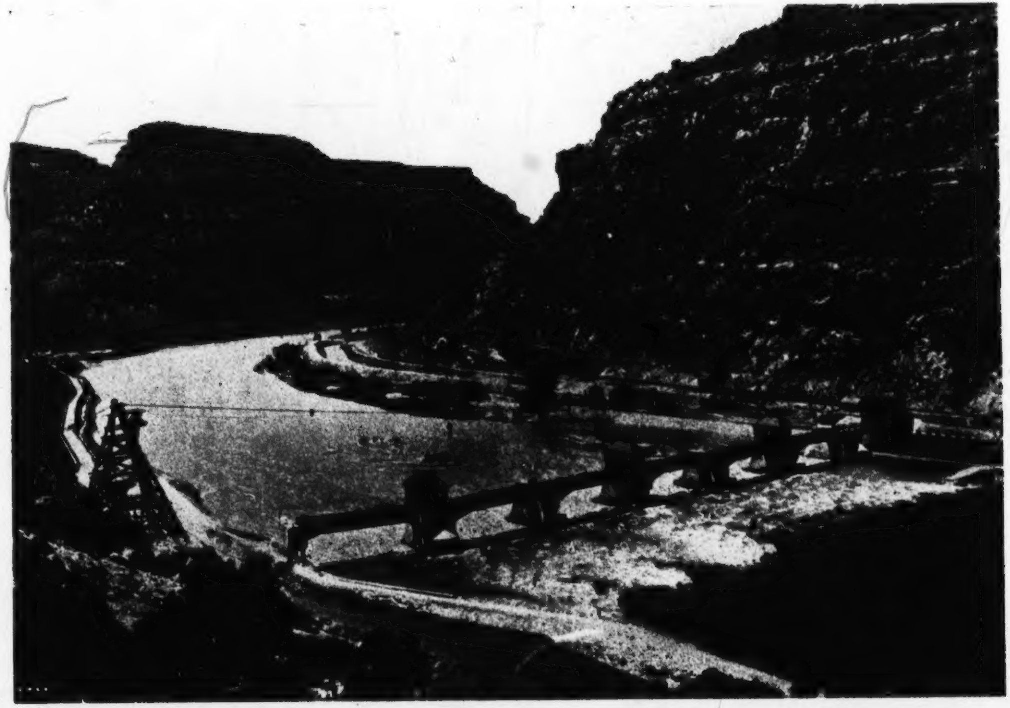
It was estimated that the total area of land in this valley susceptible of irrigation would be about 118,000 acres. The elevation of the Grand River at the mouth of the canyon is such that only 40,000 acres, all on the north side of the river, can be covered by gravity ditches starting at this point. This acreage was naturally the first to be developed and is all under irrigation from the canal of the Grand Valley Irrigation Company. To cover the remaining 78,000 acres, an additional elevation of 100 feet had to be gained. To do this it was decided to use a gravity canal diverting from the north side of the Grand River and beginning at a point far enough up the canyon to permit the use of a low diversion dam. This gravity canal would also supply water to electrically driven pumping plants to supply six separate areas of excellent land lying above the canal.

Prior to 1881, the Grand Valley was included, with the larger part of Western Colorado, in the old Ute

Indian Reservation, and the little that was known of it before that time was gained from the meagre reports of the more hardy pioneers, hunters, and trappers, and from information obtained by the Hayden expedition. Beall, one of the geologists of this expedition, describes this section of the country as "for the most part a desert, covered with a sparse growth of stunted sage brush, which grows in a stiff alkaline soil made from the debris washed from the Book Cliffs," and this opinion prevailed for years.

In August, 1881, the Indians were removed to the Uintah reservation in Utah, and on September 4th the lands in the Grand Valley, which had been partially surveyed during the summer, were thrown open for settlement. Large numbers of people were waiting in the frontier towns, and, when the word came, there was a rush of settlers seeking to secure the most desirable lands. In a short time the city of Grand Junction had been founded and all the lands along the north side of the river taken up, these lands being the most desirable since they could be more readily brought under irrigation.

Early in 1882 work was commenced on the first irrigation ditches in the valley, and four were built within the next two years. In 1886 these four ditches were consolidated and thereafter operated under one management as the Grand Valley Canal. Meantime, the development of the valley had been rapid, and, in 1886, it was estimated that 10,000 acres of land were under cultivation. With the completion of the Grand Valley Canal, all of the lands in the valley which could be watered at a low cost, comprising about 45,000 acres, were brought under ditch.



ROLLER CREST DIVERSION DAM AND CANALS, GRAND RIVER
GRAND VALLEY PROJECT, COLORADO

From this time until the passage of the Reclamation Act in 1902 a large number of survey lines were run and many attempts were made to accomplish the construction of the so-called High Line Canal by private enterprise. The apparently unlimited volume of water going to waste annually down the Grand River, and the thousands of acres of fertile land awaiting only the application of water to transform them into productive orchards and farms, made the project appear very attractive.

While favourable conditions were reported by local engineers, the difficulties seemed to be too great for private capital to overcome, and at the time of the passage of the Reclamation Act nothing had yet been accomplished toward the construction of the High Line Canal. Immediately after the approval of the Reclamation Act, local citizens requested the examination of their plans looking toward its construction by the Reclamation Service.

From the favourable reports which had been made, the project appeared worthy of consideration, and steps were taken at once to place a party in the field for the purpose of making a detailed survey of the proposed canal. As a preliminary to the field examination, the lands involved were, on July 17, 1902, temporarily withdrawn from entry under the terms of the Reclamation Act.

Before sufficient time had elapsed to allow the Service to proceed with work in accordance with the results of this examination, representations were made to the Department by certain citizens of Grand Junction, and others, that private parties were desirous of building the system. Relying upon the favourable reports made by the engineers of the Reclamation Service, to secure the capital necessary to build the canal, these persons saw an opportunity to reap promoters' profits, which would be lost if the work were done by the Government.

At that time the principle had been adopted of noninterference with private enterprise. It was still popularly believed that irrigation investments could and should be made a source of individual profit. The people as a whole had not been educated to see that work of this kind could not be a safe investment and it was only after practically every large private irrigation project had become bankrupt that this underlying principle was recognized. Under these conditions it was deemed wise for the Reclamation Service not to intrude upon what then appeared to be a proper field of private or corporate effort, and to hold off. Had this not been done there would always have been the complaint that the Government had interfered with private affairs and that the work could have been done cheaper in some other way. Doing away with this fallacy was possibly worth the loss of time which necessarily ensued.

During four years of waiting, however, nothing locally was accomplished and in 1907 the Service was again urged to take up the construction, but as a great deal of expensive work had been undertaken on other projects by this time, there was not available in the fund a sufficient amount for any large expenditures such as the Grand Valley plans required, before 1910. The co-operative plan of work had been inaugurated shortly before this time, and the idea was conceived by the Water Users' Association of raising a sufficient sum to enable the work to proceed with more rapidity. Subscriptions were solicited by the Association and in October, 1908, approximately $125,000 had been subscribed in cash and labour. A representative of the Association was sent to Washington, who on October 15, secured from the Secretary of the Interior the tentative approval of a form of contract, providing for the early commencement of work under the co-operative plan.

This contract provided in brief that the Secretary should allot the sum of $125,000 to be available for expenditure on the project during the year 1909, at the same rate the amounts subscribed by the Association should be expended; the latter amounts to be covered by co-operative certificates issued by the Department, which could be applied at their face value in reduction of water right charges; that the allotment of $100,000 already made for carrying on the work during 1908 and 1909 should be available in addition to the new allotment of $125,000; that after the year 1909, the construction of the project should be continued by expenditures from the Reclamation Fund to the extent that money should be found available. The estimated total cost of the project as then proposed was about three million dollars.

At about the time the Reclamation Service was ready to commence operations various individuals again made representations that it should abandon the project and leave the field clear for private enterprise. The favourable conditions which existed at that time in the market for irrigation securities, together with the standing which the project had attained from the favourable reports of the Service engineers, made it appear to be a very attractive one from the standpoint of the promoter. The Water Users' Association, however, protested vigorously against any interruption with the plans of the Service, and, in 1909, construction was commenced. Work on the camp had been in progress only a few days and three of the buildings were in the course of erection, when telegraphic orders were received from Washington to suspend all work, as the question of the legality of the co-operative contract had been raised. On June 2, 1909, the Attorney General rendered his opinion, now a matter of record, declaring illegal the co-operative plan of work in general, and the Grand Valley contract as executed by Secretary Garfield in particular.

This was a great blow and from 1909 to 1912, the program for the Grand Valley Project continued to be uncertain. Then the Service decided to undertake it. Even after arrangements were successfully completed for financing the work, much time was lost because of the difficulties encountered in securing the necessary rights of way at a reasonable cost, and in reaching a decision as to the location of the main canal.

However, matters were finally adjusted, and construction commenced during the fall of 1912 on the tunnels for the main canal, and the next year preparations for the construction of the diversion dam were started. Actual work on the dam commenced August 27, 1913. From this time on, work on the entire project was pushed rapidly, and by the end of 1916 the diversion dam and headworks were comple-

IRRIGATION AND FARMING ON BENCH LAND NEAR GRAND JUNCTION
GRAND VALLEY PROJECT, COLORADO

MAIN CANAL, GRAND RIVER
GRAND VALLEY PROJECT, COLORADO

ted, and of the canal system there remained to be finished only the last seven miles of the main canal, laterals for 15,500 acres in the second and third lateral districts, the power plant and pumping system, and such drainage and flood-protection works as may be required.

In the designing and construction of the Grand River Dam the engineers had to solve the problem as to how they should raise the level of the river at low stages sufficiently to send 1,425 cubic feet of water per second into the head of the main canal, and yet at high water to pass a flow of 50,000 cubic feet per second without raising the water level to a point where it would endanger the road-bed of the Denver and Rio Grande Railway. This was effected by building a solid concrete weir, surmounted by eight massive piers and provided with seven roller crests for regulating the height of back water at the canal intake. Six of the roller crests span openings 70 feet long between piers and are 10 feet 3 inches high. The seventh roller is 60 feet long, 15 feet 4 inches high, and it regulates the flow through the sluiceway in front of the canal intake. At times of low flow the dam diverts the full flow of the river, part of which, however, is returned through the power-plant at the lower end of the canyon division. Nine gates, each with an opening seven feet square, regulate the flow into the canal. The roller crests and regulator gates are operated by electricity. A three-hinged arch steel service bridge, 6 feet in width, consisting of seven spans, extends the full length of the dam. The total length of the dam between abutments is

536.5 feet. When the rollers are closed at low river stage, it raises water about 20 feet above the general bed of the river.

A peculiar condition was found to exist in the orchard region of the main canal near Palisade, which has not been encountered elsewhere. As soon as the land is soaked with water it subsides from one to five or six feet. Where the irrigation was carelessly and unevenly done the subsidence is uneven, and in some cases a line of clearly marked difference of several feet was formed which it has been very difficult to overcome.

The soil of the irrigable area is sandy loam, and adobe; the mesas or benches are admirably adapted to the raising of fruit, while sugar beets, alfalfa, grain and vegetables are also staples. The fruit is shipped widely, even to the faraway cities of the East, while the local demand absorbs practically all of the other products.

There are twenty thousand acres of public lands on this project which will be opened to settlement under the terms of the Reclamation Act, probably in 1918.

The present Project Manager is S. O. Harper, with offices at Grand Junction, Colorado.

CHAPTER X

'MID THE SNOWY PEAKS OF THE ROCKIES. THE UNCOMPAHGRE PROJECT, COLORADO

The snow-clad peaks of Colorado always have had a fascination for a certain class of minds. Not alone are tourists, world-travellers, the wealthy, moved to deep emotion at the sight of magnificent mountain heights that aspire starward, and catch the snows of winter, holding them until the warm spring-time sends them in dashing, sparkling torrents through the deep canyons into the placid valleys below. Many a poor man, even though he be a "man with a hoe" or a city dweller, thrills with deepest emotion as he sees such peaks, though for the life of him he could not express his feelings in words. But the allurement is there, and when the suggestion of home-making is added to the mountain lure, there is little wonder that men of this type flock to take possession of such home lands as are offered. Sometimes it is the wives that long for such environment. Again, of course, it is possible that men seek these locations for no other purpose than the direct and simple one of making money, or making a home. For, whenever there are great mountain peaks and ranges there are sure to be extensive valleys where cattle raising, dairying, and farming may be successfully carried on.

In western Colorado, on the western slope of the Continental Divide, there is such an attractive mountain valley, extending from northern Delta County, southward through Montrose and into Ouray County. The Utah state line is nowhere more than seventy-five miles distant, and the area has an extreme length from north to south of above forty-five miles and a maximum width of about fifteen miles. It contains 381 square miles, or 243,840 acres, of which about 100,000 are comprised within the Uncompahgre Project of the Reclamation Service.

The area is bounded on the west and southwest by the Uncompahgre Plateau, on the south and southeast by the San Juan Mountains, and on the east and northeast by the Cimarron Ridge and Vernal Mesa. Toward the northwest is the continuation of the valley. This surrounding high land ranges in elevation from 8,000 to 14,000 feet above sea level. Montrose, the chief town on the project, is 5,800 feet.

There are five physiographic types within the valley, namely, 1, the comparatively narrow alluvial belts bordering the main stream channels; 2, the broad terraces, representing former alluvial plains of the same streams; 3, smooth slopes, alluvial fans, and broad, smooth coves with strong downward slopes around the heads of small drainage basins—this type occurs exclusively on the east side of the Uncompahgre River; 4, small, usually isolated, hills of shale that have not yet been reduced to grade level; and, 5, remnants of former alluvial fans which existed when the valley floor was a few hundred feet higher than at present. It is the three first types alone that are irrigable, and are included in the lands of the project.

The area was a part of the reservation occupied by Chief Ouray's band of Utes prior to 1881. The Indians cultivated small patches of land, raising chiefly beans and potatoes. The naturally watered meadows were used extensively for pasturing their ponies and sheep. Promptly upon the removal of the Indians to their Utah home the country was opened to pre-emption and claims were filed. Most of the early settlers were native-born Americans from other parts of Colorado and from neighbouring states. They established themselves along the Uncompahgre and Gunnison rivers, where water could be most easily turned upon the fields, the vicinity of Montrose being some of the first territory settled. A steady influx of settlers followed. The chief occupation, naturally, is farming.

In the fall of 1882 the Denver and Rio Grande Railroad was extended from the east into the region as far as Montrose on the Uncompahgre, and down that stream and along the Gunnison to Grand Junction, the important railroad centre some fifty miles to the northwest. A branch line was built up the Gunnison and its North Fork to Somerset, about thirty-five miles eastward, in 1901. In 1888 and 1889 another branch was built up the Uncompahgre from Montrose to Ouray, about twenty miles beyond the region in which we are interested. It now gives free access to Telluride and other mining towns in the southwestern part of Colorado. No part of the region is farther than fourteen miles from a railway and with the construction of a projected electric line connecting Cedar Ridge in the northern end with Uncompahgre Valley points, no part will be over seven miles distant.

Montrose, the largest town of the area, has a population of about 4,000. It is the commercial centre of a rich and rapidly developing farming section. It is the junction point of the standard and narrow gauge divisions of the railway system, and is the gateway to the great San Juan mining country. It owns its own system of mountain water, has seventy-two miles of cement sidewalk, is well sewered, owns its electric-light plant, has daily, one semi-weekly, and two weekly newspapers, nine churches, all the secret societies, fine grammar and high schools, women's clubs and all the accessories of cultured and progressive western civilization. It is the county seat of Montrose County. Delta, the county seat of Delta County, also on the project, received its name from the expansion of river plain at the confluence of the Uncompahgre and Gunnison rivers and is next in size with 2,500 inhabitants. Like Montrose, it is located in a rich agricultural section. These towns furnish good local markets and are also important as shipping points. Olathe, another town, now has a population of about 600. In 1912 it was able to ship more than 1,100 carloads of farm products. The town has well laid cement sidewalks, owns its water system—a pipe-line, twenty-three miles long, bringing pure mountain water from springs in Dry Creek Basin—and in 1914 completed its own sewerage and drainage systems. Austin, Colona and Cedar Ridge are other towns of Delta and Ouray counties but not in the project, the latter alone not being on the railway, but proud in the possession of a nearby vein of good coal, which is being profitably worked.

The valley has a creditable system of roads. On nearly every section-line in the thickly settled parts a highway has been laid. Some of the unimproved road-beds become sticky in wet weather, but these are gradually being converted into highways. The dominant interest throughout is agricultural, with the crafts it supports. Grazing, lumbering, and mining are important on the adjacent hills.

The climate of the region is one that gives the distinctive four seasons that seem best adapted to civilized man. The winter, however, is not at all severe. Spring may be said to open in late March or early April in the lower parts of the region, and about two weeks later in the higher. Many apricot, peach and plum trees bloom in April, and some vegetables are planted early in that month. The records show that there is an occasional killing frost that occurs as late as May 16th, and as early as October 2nd. The average growing season for plants sensitive to frost, therefore, is from four and a half to six months. The temperatures permit growing successfully nearly all crops common to the same latitude eastward, including corn, which is held back by the cool nights of the higher sections.

There are none of the prolonged severe winds that are known on the plains further east, as the mountains rise several thousand feet in protection and shelter. Tornadoes are unknown. Rather brisk southwesterly winds, producing dust storms and often followed by showers, characterize the afternoons of late spring and early summer. Occasional hailstorms, usually following narrow paths, damage the fruit crop to some extent.

The precipitation within the area is rather equally distributed throughout the seasons and probably averages less than nine and a half inches. The areas above 6,000 feet elevation have, perhaps, slightly over ten inches of rain, and those under 5,300 feet less than eight inches. Staple crops, therefore, require irrigation.

The surrounding plateaus and mountains which furnish the water for irrigation have a much greater rainfall. These rains come mainly in summer. The winter precipitation falls chiefly as snow, much of it remaining as late as midsummer. A striking feature of the region is its low humidity. This accounts for the wonderful clearness of the atmosphere. Montrose averages from 240 to 280 clear days in the year, and naturally the whole district is peculiarly and happily healthful.

After the removal of the Indians and the influx of the white settlers it was soon found necessary to resort to irrigation. When the Service began its work it found 110 canals and laterals, having an aggregate length of nearly 500 miles, constructed by private enterprise. Most of these have been acquired by the Government under a general comprehensive plan for the unification of the irrigation work of the valley. They have been standardized, their wooden headworks largely replaced with substantial concrete structures, wooden flumes replaced by steel flumes on concrete pedestals, etc. In one place, where a depression 3,800 feet wide and a maximum depth of about 200 feet had to be crossed with about 42 cubic feet of water per second, an iron pressure-pipe was installed, and, a distinctive feature of the East Canal,

In the Heart of Gunnison Canyon, near the Tunnel
Uncompahgre Project, Colorado

above Olathe, is the Garnet Mesa Siphon, which delivers 25 second-feet of water to about 1,825 acres through a wood-stave pressure-pipe 8,560 feet long, under a maximum head of ninety feet.

Under the old private canal-systems shortage of water, with consequent loss, was frequent. This led not only to much irritation, but also to litigation which rendered habitation in the valley undesirable. To relieve this situation, and irrigate the lands that no private system had yet reached, became the task of the Reclamation Service. To accomplish this it was necessary to secure far more water than had hitherto been available. As early as 1890 L. C. Lauzon conceived the idea of bringing the waters of the Gunnison River into the Uncompahgre Valley, and private capital with state aid attempted the task; in December, 1901, a tunnel was located northeast of Montrose, and about six miles northwest of the present Gunnison tunnel and work began upon it. But early in the fall of 1902, after having driven 900 feet of tunnel, the funds were exhausted and the work was suspended.

When the Reclamation Service undertook the work the State conveyed its rights to the Government, and on June 7, 1904, the Secretary of the Interior authorized the expenditure of $2,500,000 for the Uncompahgre Project. The most important feature of the work was the bringing of the Gunnison River, which flows in a deep canyon to the eastward, roughly parallel to the Uncompahgre, into the valley. To explore the canyon of the Gunnison was an heroic task, and the story of this achievement gives one thrills of admiration for the bravery of those who dared it. Three or four boats that started down were wrecked in the rapids and one of the adventurous party nearly lost his life, but the site of the tunnel was found. When built this was 30,645 feet in length, has a uniform grade of 2.02 feet per 1,000 feet, the bottom is flat, 10 feet in width. The sides are straight, 10 feet high with a batter outward of 6 inches, the roof is arched with a span of 11 feet and a rise of 2.5 feet within the concrete lining. The entire area of the cross-section inside the concrete lining is 122 square feet, the water carrying cross section is estimated at 100 square feet and the discharge is estimated at 1,300 second feet.

The original contractors were unable, through want of capital, to carry on the work, and after four months their financial failure compelled the Service to undertake the work with its own force, the new bids submitted being deemed far beyond a reasonable cost. There were great difficulties experienced in accomplishing this task. Sometimes the pressure of inflowing water was so great as to eject the powder-charges from the drill-holes before they could be exploded. In December, 1906, a flow of water of more than a million gallons per hour was tapped. Accompanying this water was an enormous volume of carbon dioxide, which drove all the men from the tunnel and compelled the temporary abandonment of the work. After about three weeks entrance was again gained, but the flow of gas was so strong and shaft about 9,000 feet from the west portal of the tunnel 700 feet in depth as an aid to ventilation. the temperature so high that work was impossible. To overcome this difficulty, it was decided to sink a

The excessive humidity, the high temperature, and the swelling ground so rotted and weakened the timbers, with which the tunnel temporarily was lined, that it was found necessary to start lining the tunnel with concrete.

These were but some of many difficulties encountered and overcome, for the excavation work was completed July 6, 1909, and on September 23, of the same year, with great rejoicing, President Taft formally opened the tunnel. The actual completion of all the work has not yet been accomplished, as it is to be cement-lined throughout. The first water for irrigation purposes was delivered through it on July 6, 1910. The flow of water has been gradually increased from year to year until 750 feet were carried for a considerable length of time in 1916.

A diversion dam was also built in the Gunnison River to divert the water into the tunnel. This is a rock-filled crib structure, with a crest 240 feet long, 18 feet wide, and an apron 42 feet wide. In front of the intake gates a sluiceway has been provided to prevent the accumulation of gravel. This has two cast-iron gates, each six by eight feet, operated by hand.

The South Canal is the chief work outside of the tunnel. It extends from the west portal of the Gunnison Tunnel, eleven and a half miles, to the Uncompahgre River. It has a capacity of 1,300 second-feet, and irrigates 13,600 acres.

As a larger acreage is brought under cultivation it will be essential to insure absolutely a sufficient supply of water. The present reliance is upon the Uncompahgre and Gunnison rivers which are fed by melting snows. They begin to rise when the snow melts in the spring, reaching culmination sometime in June, and then declining irregularly until winter. The maximum demand for irrigation is usually later than the maximum flow of the streams, and does not decline so rapidly. The combined flow of both streams available for irrigation in the Uncompahgre Valley is usually sufficient for the requirements of the area to be included in the complete project, though sometimes there would be a slight shortage in August or September. In 1902, which was a phenomenally dry year, there would have been a shortage of over forty per cent.

To provide, therefore, against contingencies, the Service has in mind the possibility of erecting a masonry dam on the Taylor River, a tributary of the Gunnison, having a drainage area of 253 square miles. This would give additional storage of 106,000 acre-feet.

With the abundance of water provided, the farmers of the Uncompahgre Valley are now able to work most successfully. There has been considerable dissatisfaction, however, at the cost of the project. The settlers have contended that they were to have water at a less charge per acre, than what the project has so far cost. To adjust this difficulty, however, a conference was held in 1917 making clear, among other matters, that the originally assumed costs did not include the later consolidated and improved canal systems. As the times of beginning the payment have been extended five years a suitable and amicable adjustment was made, and the farmers have gone to work with zeal. While in the past they have confined themselves largely to alfalfa, potatoes, wheat, oats, sugar-beets, and onions, they are now beginning to awaken to the desirability of more diversified farming and a steady rotation of crops. A flouring-mill has recently been established; in due time there will be a beet-sugar factory, and when incoming settlers are willing and ready to listen to the advice of a practical farmer as to locations, methods of work, etc., it is possible an advisory farmer will be provided. The live-stock of the region is famous, the cattle being allowed free and open range in the mountains during the summer, being brought up and fed in winter when range-feed is scarce. Dairying, however, is rapidly on the increase, home demand for butter alone not yet being supplied, for commercial reports show that Montrose County alone consumes $900 worth of butter per week more than it produces.

In fruits, apples, pears, plums, and cherries do well, and while frost occasionally pinches peaches and apricots, there are some regions in which they thrive and are profitable.

Smudging for prevention of injury by spring frosts is systematically carried out as is done in the orange-groves of Southern California. This is a procedure of placing small sheet-iron buckets or stoves in the orchards in which coal or crude oil is burned. The heat thus generated by, say, about one hundred buckets or stoves to the acre, raises the temperature and thus obviates fruit destruction by the frosts.

The estimated cost of the entire project when completed, including Taylor Park Reservoir, the construction of which has not been decided upon, is in the neighbourhood of nine or ten million dollars.. The charge to the settler, depending on the ultimate acreage, will be payable in the twenty years now allowed by the Government. The public lands of the project will probably be opened in the fall of 1917. Announcement of this will be made in due time. The farm unit will be forty acres, though lands bought in private ownership may be irrigated to the extent of one hundred and sixty acres.

The Project Manager is Fred D. Pyle, with office at Montrose, Colorado,

CHAPTER XI

ON THE WESTERN TRAIL. THE BOISE PROJECT, IDAHO

The Snake River Valley was one of the main travelled routes from the East to the Pacific Coast, in 1863. Fort Boise was established for the protection of the emigrants coming to southwestern Idaho, on account of the historic gold rush of 1862. In the same year Boise City was laid out on the plain between the fort and the river.

During the ages of the formation of the valley of the Snake River and its tributaries, the Payette and Boise valleys, a series of volcanic craters located along its northern boundary, sent forth streams of lava, which flowed across it to the southwest. Successive eruptions followed, at periods of ages, and between each there was formed a layer of soil and disintegrated rock. Since the last overflow the glacier period has come and gone, and the upper and lower ends of the valley are seared with deep gashes cut by the glaciers, and great moraines of sand and gravel have been left on the surface of the plain. The soil of this section is volcanic ash mixed with disintegrated lava, and the sand and gravel of the glacier moraines, a combination that insures one of the richest, most productive and lasting of soils.

Careful reconnoissance showed that here were nearly 400,000 acres of land to be reclaimed and turned over to settlers whereupon to establish homes and thus enlarge their happiness and the growth of the country. What wonder that it awakened a large vision in the minds of the engineers.

On the western slope of the Sawtooth range of mountains, in Idaho, the Boise River—a tributary of the Snake—heads in a watershed of 2,650 square miles. After it leaves the mountains it adds 1,000 square miles more of foothill and valley area to its watershed.

Most of its water supply is derived from the melting snow in the mountains, and therefore has the usual irregularity of flow characteristic of such streams, viz.: a low stage in the winter, while the mountain streams are frozen; a rising stage with the progress of spring, reaching a culmination somewhere in June, and declining during July and August as the snows disappear, reaching a minimum again in winter. The regularity of this ir-regularity is varied, at times, by rainfall and fluctuations of temperature, but such snow-fed streams are far more dependable for a constant water-supply than are those that rely upon rainfall.

This project provides for the storage of these waters at Arrowrock, about 20 miles above Boise, and at Deer Flat, and their use upon over 200,000 acres in the Boise Valley. (By the way let me suggest that the reader unfamiliar with the name do not pronounce this as a word of one syllable. It is properly and commonly made into two syllables and pronounced *Boy—sy.*) The water of the Boise River is diverted by a dam about eight miles above Boise, whence it is distributed on the south side of the river by the Main South Side Canal leading from the dam to the Deer Flat Reservoir; through laterals heading in the Main Canal; canals heading in the Deer Flat Reservoir; distributing canals heading in the river below the Boise River Dam; then distributing water on the north side of the river to a small area of land east of Boise, through a canal system heading at the Boise River Dam. Altogether the project will have over 980 miles of canals.

The Deer Flat Reservoir covers 9,835 acres and has an available capacity above outlets of 177,000 acre-feet.

At the point where the canyon of the Boise River spreads out fanlike and merges into the flat slopes of the arable lands of the lower valley is placed the Boise Project Diversion Dam, this being, as just stated, about eight miles upstream from Boise. It is 35 feet high and 400 feet long and is built of rubble concrete—large blocks of lava embedded in concrete of the usual consistency—and backfilled on the upstream side with earth and gravel. It is provided with a logway, on account of the importance of the logging industry in this section. This logway is provided with a movable crest which is raised when logs are passing or during periods of high water, and lowered during the remainder of the season to increase the head on the power plant. At the east end of the dam is a small gate for diverting water to a canal leading to the farm of the State Penitentiary near Boise, and at the west end are the diversion works of the main canal of the Boise Project. A fish-ladder is also provided next to the logway.

For the diversion of the river during construction, two parallel tunnels were provided in the left bank, each six by eight feet, closed by cast-iron gates.

These tunnels are 160 feet long and lined with concrete, and recently a third parallel tunnel has been built, and all are used as tail-races in the development of power, and the power-house built over them. They are controlled by butterfly gates, each nine by twelve feet, protected by a grillage in front.

This power plant at the diversion dam was built primarily for furnishing power during the construction of Arrowrock Dam. Its capacity is 2,700 H. P. but this is decreased during low stages of the river. Since its completion, in 1912, it has not only furnished power for Arrowrock, but has run the Government electric dredges used in digging the ditches in the lands being drained near Caldwell in the Pioneer drainage district, and through arrangements with one of the private companies operating in Boise, has been used to run the street cars and light the homes in Boise.

It operates under a head of approximately 30 feet and is equipped with three generators.

The Main Canal heads on the east side of the diversion dam and follows the course of a small canal which was acquired in 1906 from the New York Canal Company and Idaho-Iowa Lateral and Reservoir Company. Twenty-three miles below the heading the water discharges into Indian Creek and is again diverted to a canal eight miles long leading to Deer Flat Reservoir, an inland reservoir set in the midst of the project. About seven miles of the upper section of the main canal has been lined with concrete and has a bottom width of 40 feet. The unlined portion has a bottom width of 70 feet. From the Diversion Dam to Indian Creek the capacity is 2,500 second-feet and the lower portion discharges approximately 1,500 second-feet.

Deer Flat Reservoir forms a lake within the project. This was originally an expanse of level lying land called the Deer Flat, and partially irrigated from one of the old canal systems of the valley. A hill lying toward the northern end and rising from the flat made it possible to close the narrow spaces between this hill and the surrounding high land with earthen dikes. These are known as the Upper and Lower Embankments.

The chief engineering feature of the project, however, is the Arrowrock Dam. The canyon, the chosen site, has high bare granite cliffs on the north side, with a less precipitous slope on the south, the foot of the slope being capped with a wedge of basalt, nearly perpendicular at the river, forming a cliff 70 to 80 feet high, with a level bench intersecting the granite slope further back. This bench and the granite slope above it were covered with a layer of soil and some vegetation. The site of the dam was thoroughly explored with diamond drills, showing a foundation of good granite at a maximum of 90 feet below the bed of the river, and a depth of 60 to 70 feet over most of the foundation, the overlying material consisting of gravel, sand, and boulders suitable for use in concrete.

Preliminary to the construction of the dam, a standard gauge railroad 17 miles long was built from Barberton, the end of a railroad spur out of Boise, to the dam site. Regular train service over this line has been maintained since its completion in November, 1911, and during the first four years it hauled about 80,000 passengers and nearly 15,000,000 ton miles of freight.

The maximum height of the dam is 348.6 ft., its length is 1,100 ft., it contains 585,200 cu. yds. of concrete and it has a gravity section but is built on a curve of 660 ft. radius. There are 20 outlets through the dam, three of them 6 ft. and the rest 4 ft. 4 in. in diameter, each controlled by a 58-in. balanced needle valve set on the upstream face. These outlets are arranged in two sets of ten each, the upper set being about 110 ft. below the top of the dam and the other set about 90 ft. lower. There are also, just at the old river level, five sluicing outlets 5 ft. in diameter, each controlled by a sliding gate. All gates are operated from chambers within the dam. Inspection galleries, of which the control chambers form a part, give access to the interior of the dam at several different elevations.

The spillway has a capacity of 40,000 sec.-ft. The weir is 400 ft. long and extends back upstream from one end of the dam at about a right angle to a tangent to the curve at that point. A discharge trench picks up the water along the toe of the weir and carries it past the end of the dam to the canyon of a creek that enters the river a few hundred feet below the dam. This spillway trench was excavated through solid rock, and is lined with concrete. The whole of this work was done by the forces of the Service.

As already stated, the canals of the Boise Project serve lands lying above those previously irrigated by private enterprise. Most of them are rolling bench lands, and although some bottom-lands on the right bank of the Snake River are also included, these are

Arrowrock Dam and Reservoir
Boise Project, Idaho

generally sandy and rough. The system for distributing irrigation water, therefore, is complicated and expensive, requiring tortuous canals, and a large number of drops, chutes, pressure-pipes, etc. These are generally of concrete for the sake of safety and permanency, though a few problems were successfully solved by means of steel and wood. In lowering water from the bench to the Snake River bottom several drops of great elevation were needed. The smaller were in the form of pipes and the larger were open chutes located where the necessary fall is compressed into the shortest practical distance.

It was decided early in the construction of the project that to facilitate it a telephone system, controlled by the Service, would be needed. Consequently in March, 1910, work was begun and at the close of that year the main trunk lines of the system were completed. By the close of 1911 there had been completed about 158 miles of telephone line. This system has since been extended so that at present there are 167 miles of metallic circuit operated by the Service, which gives connection with the headgates, waterways, watermasters, and ditch-riders. The central switchboard is located at Boise, Idaho, where day and night service is maintained. It is largely due to the telephone service that serious breaks in the canal system have been avoided.

Beginning with the season of 1907, when the management of the operation of the New York Canal was assumed by the Reclamation Service, it has, each year, delivered water through this canal to the stockholders of the New York Canal Company, in accordance with the contract with that company. During the year 1907 about 10,000 acres of New York Canal Company lands were irrigated and this amount has gradually been increased until at the present about 20,000 acres are being irrigated.

During the year 1909 the Service furnished water to project lands for the first time, amounting to approximately 4,000 acres. This has been increased at the present time to approximately 112,000 acres. This amount of land represents that in actual cultivation and is scattered over 230,000 acres for which the Service is now prepared to deliver water.

Practically all of the public land of the project has been entered, but there are approximately 3,400 acres of irrigable unsold State land under the project.

The opportunities of new settlers lie in the subdivision and disposal of public lands by parties now holding them, through assignment, and by the purchase of private land or lands owned by the State.

Besides the older towns of Nampa, Caldwell, and Meridian, there are the smaller towns of Kuna, Bowmont, Melba, Greenleaf, Huston, and Wilder that have been located on the project and owe their growth entirely to its development.

The best measure of an irrigation project's success is found in the crops produced thereon. In 1916 over 2,300,000 dollars' worth of produce was harvested. This was from the 72,500 acres then under cultivation upon which crop reports were taken, about one-half of the project. The average farm value of the crops per acre was $32.07.

The value of livestock owned by the settlers at the close of 1916 was over seventeen hundred thousand dollars, and the development in dairying and stock growing is proceeding at a rapid rate.

The principal products are alfalfa, wheat, oats, potatoes, apples, prunes, and small fruits.

The average elevation of the irrigable area is 2,500 feet above sea level, and the average rainfall for 35 years is 13.5 inches. The temperature ranges from 28° below zero, to 107° Fahr. Very little snow falls, and what does usually melts quickly. The ground is usually entirely free from snow for eleven months of the year. The atmosphere is clear and bracing, severe winds are unknown, and there is continuous sunshine, as a rule, throughout the growing season.

With such favourable winter and summer weather therefore, combined with an abundance of rich pasturage, and comparatively little disease, all conditions render this region eminently suitable to the profitable raising of stock, including cattle, hogs, sheep, and horses. A considerable amount of winter feeding of sheep from the open range is done. Portland, Ore., Omaha, Kansas City and Chicago furnish the principal markets.

There are many dairies being conducted along scientific lines, and each year shows a satisfactory growth in this direction. A few farmers' co-operative creameries have been established on or in the vicinity of the project, and these are operating successfully. Dairying products are consumed partly by a generous local demand, and partly by the outside markets.

The farm unit is 80 acres of irrigable land, and the construction cost about $80.00 per acre, payable in twenty years without interest.

The present Project Manager is D. W. Cole, with offices at Boise, Idaho.

CHAPTER XII

BY THE RIVER OF THE SNAKES. THE MINIDOKA PROJECT, IDAHO

Named after a branch of the great Shoshone family of North American Indians, the Snake River, the name is a misnomer, for it has nothing whatever to do with snakes. Yet as it has been in use for over a century we may as well accept it, for anything a century old in the United States already has the authority of antiquity. Hence we have the Minidoka Project, with its source of water-supply in this river of the Snakes. This is no mean river, as one may learn who reads Lewis and Clark's account of it as they journeyed westward on their tour of exploration. It heads—in one of its numerous branches—in or near the Yellowstone National Park, and occupies the same relative position to the southwest of that scenic wonderland, that the Shoshone River does to the northeast.

This project was one of the earliest undertaken by the Reclamation Service and for that reason, as well as several others, its history is both interesting and important.

At the time it was started it was expected that the Service would build the storage and diversion works and the main canals, while the settlers would be able to build and operate the laterals from the main canals to their own farms. It was soon found, however, that this method resulted in a great deal of friction in a new community, with unsatisfactory results to the project as a whole. The policy, therefore, was changed and most of the laterals built by the settlers have been purchased by the Service and made a part of the complete system, which delivers water directly to the farms.

The project, at the time it was initiated, consisted of public land and unsold State school lands. There were only two or three pieces of homesteaded land, which had been patented within its boundaries. However, as soon as it was known that the Reclamation Service contemplated the construction of the project, settlers rushed in and the land was soon all taken up. These settlers had to wait for several years before the canals were completed, and it was possible to deliver water to them. Many of them were not farmers and did not know what work of preparation it would be necessary to do before they could water their lands. Most of them found work of one kind or another upon the construction of the works, but for practically all of them the years were years of extreme hardship and discouragement.

It was a recognition of this fact on this and one or two other projects that led to the withdrawal of all public lands from settlement upon even contemplated projects, or those upon which construction had begun, until the work was declared completed.

The irrigation plan provides for the diversion of the waters of the Snake River by a combined storage, diversion and power dam about six miles south of Minidoka, Idaho, into two canal systems, one on either side of the river, watering lands in the vicinity of Acequia, Rupert, Heyburn, and Burley, Idaho.

Power developed at the dam is utilized primarily for pumping water from the canals to irrigate high lands, but also for pumping for drainage purposes and for furnishing heat, light, and current for commercial use to the towns on the project, and the farms adjacent to them.

Storage is provided mainly by a reservoir constructed in the upper drainage basin of Snake River, at Jackson Lake, Wyoming. This is supplemented by the reservoir formed by the Minidoka Dam and known as Lake Walcott, in recognition of the work of Hon. Charles D. Walcott, formerly Director of the U. S. Geological Survey, now Secretary of the Smithsonian Institution. Jackson Lake Dam, as originally planned, and Minidoka Dam are finished, though the former was raised seventeen feet higher after completion of the first unit, giving the lake a capacity of 790,000 acre-feet. The irrigation system for the gravity unit and the southside pumping unit and the drainage system for the gravity canals are still under construction.

The area of the drainage basin is 22,600 square miles above the diversion dam; the annual run-off in acre-feet, of Snake River at Montgomery's and Howell's Ferries and Neeley (16,000 square miles), from 1896 to 1914, was, maximum, 8,900,000; minimum, 3,830,000; mean, 6,971,000. The South Fork of Snake River at Moran, Wyo. (980 square miles), 1904 to 1914, maximum, 1,640,000; minimum, 920,000; mean, 1,310,000.

The average rainfall on the irrigable area for nearly ten years is 12.62 inches, and the temperature ranges from fifteen degrees below zero to one hun-

SPILLWAY OF THE MINIDOKA DAM, AND LAKE WALCOTT. ELECTRIC POWER-HOUSE IN THE BACKGROUND
MINIDOKA PROJECT, IDAHO

dred degrees Fahr. The average elevation of the land is 4,225 feet above sea level, and the length of the irrigating season is from April 1 to October 31, 214 days.

In one of his lectures on the Reclamation Service Mr. C. J. Blanchard, the Statistician who makes his figures both eloquent and poetic, said in regard to the project:

> In the Spring of 1904, I camped for the night on the banks of Snake River, Idaho. My companion, the engineer, D. W. Ross, confided to me two plans for a great work in this section, which was to create in the desert a garden covering twenty-five square miles. He drew his plans roughly in the sand as we sat by the campfire.
>
> "Here," he said, "I shall build a dam to turn the waters into huge canals on either side."
>
> When I returned another year the dam was finished. Pointing to a landscape of desolation, whose outer ends touched the sky, and on which there was no sign of human habitation, he said: "This desert will one day become a show place—a garden rich and productive, and supporting in comfort a thousand families."
>
> Last year, standing where I did three years before, I realized that the engineer's dream had come true. Look where I would, in any direction, I saw no desert. Cultivated fields, with harvests ready for garnering; pleasant little homes on each forty and eighty acres; children playing in the sunshine, sturdy and happy; the garden crops being gathered for winter-storage, gave abundant evidence that the soil was productive, and, when watered, gave generous reward to the farmer.
>
> Twenty-two hundred families are living here today, when only a short time ago there was no sign of human life. Four prosperous towns, soon to become cities, have sprung up along the new railroads. This is a transformation to make you rub your eyes with wonder and amazement.

This was nearly ten years ago, and developments have continued rapidly during this period, hence the reader may well strive to imagine what the results are today.

The delivery of water began on the gravity unit in 1907, and on the pumping unit in 1909. Gradually since that time the handicap of sandy lands has been overcome and today the Minidoka Project is one of the most prosperous, not only in the Reclamation Service, but in the West. The settlers are getting on their feet and have learned the necessity of diversifying their crops. With this have come better prices and better feeling. Practically all of the ne'er-do-wells have been eliminated and their places have been taken by new men who are able to take advantage of their opportunities and improve their own condition, as well as the project as a whole.

Today out of 70,000 acres under the Gravity Canals 45,000 acres are in actual cultivation. Of 49,000 acres under the South Side Pumping canals 41,000 acres are in cultivation. Some 3,000 acres of State lands are as yet unsold and there are a few homesteads not yet entered, most of these latter, however, are poor and contain only a small area of irrigable land, most of which is sandy or has some other bad feature. Improved farms are selling at from $75 to $200 per acre, and near the towns prices of $300 per acre are frequently reached.

On the Gravity Unit of the project the rise of underground water early became a serious problem. At one time nearly one-half of the gravity area was threatened with serious damage from seepage. Numerous deep drains have been dug to conduct this water off the project, and now the problem is satisfactorily solved. Much of the work was done at a very low cost with electricity developed at Minidoka dam. Of the whole area which at one time was endangered, less than 600 acres now are troubled by water and this is practically all in ponds which are too low to be successfully drained.

Until July in ordinary years the project has an ample supply of water from the natural flow of the Snake River. After that time the needs of the project are supplied from the large storage reservoir above noted known as Jackson Lake in Wyoming, which is only some 15 miles south of the Yellowstone Park. The flow from this reservoir is supplemented by a smaller quantity from Lake Walcott, which is formed by the back-water above the diversion dam for the project, near Minidoka. This latter reservoir is a great convenience and advantage to the project, as its 50,000 acre-feet capacity forms an equalizing basin, which can be drawn upon at any time by the canals. In getting water down from Jackson Lake through a stretch of the Snake River, 250 miles long and out of which some 50 canals take water, there are necessarily some uncertainties and irregularities in the flow. This would be quite a handicap to the operation of the project, were it not for the reservoir capacity always available in Lake Walcott.

At the diversion dam and on the shores of the Lake the Reclamation Service maintains a beautiful little park which is taken advantage of by the settlers for recreation and amusement. Lake Walcott is from one to four miles wide and about 10 miles long.

Above this the diversion dam has backed the water into the narrow channel of the Snake River for an additional twenty miles. All of this water is navigable for comparatively large boats.

The Minidoka Dam is a combination of rockfill backed with earth on the water side, built in a gorge of the river, and continued on the basalt mesa to the south, in the form of a concrete weir, which serves as a spillway. The weir is provided with a movable crest, consisting of a series of buttresses against which are placed flash-boards to store flood waters for irrigation. Before the height of the flood season in early June the flash-boards are removed to allow the floods to pass over the weir, and as the floods subside the boards are replaced in order to hold and store as much of the surplus waters as may be. The available storage capacity above the level necessary for diversion purposes is about 54,000 acre-feet, and the area of the lake at full capacity is 11,350 acres.

The dam and headworks were built by contract in 1906 and 1907. The contract included a portion of the North Canal in rock section.

As it was desirable to consolidate the rock of the dam two aerial cableways were provided, each having a span of 1,150 feet with a capacity of seven tons, and the rock was dropped from 20 to 60 feet, thus crushing it closely together.

The earth fill was composed chiefly of sand and gravel, with selected material containing clay for the water slope, which was protected by rip-rap of basalt rock.

A concrete core wall was built on bed-rock entirely across the river, and brought from 5 to 13 feet up into the fill at the up-stream toe of the rockfill, forming a water-tight junction between the earth and bedrock.

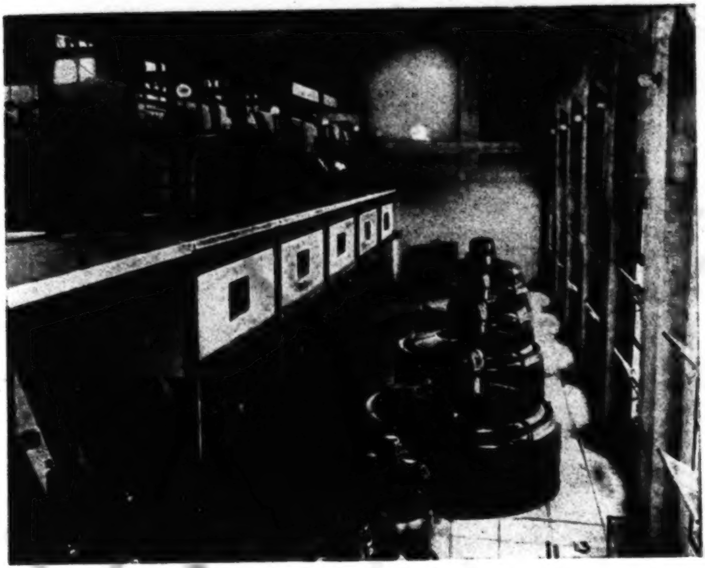
There are two projects in the vicinity of Twin Falls, Idaho, which have a prior right to the natural flow of the Snake River and which divert their water about 35 miles further down the river. A large stream of water for these projects is therefore always passing the Minidoka Diversion Dam. Advantage is taken of this to develop 10,000 electrical horse power. This power is used in the summer time to pump water to 49,000 acres of high land lying south of the Snake River. The water is pumped to a maximum elevation of 90 feet in three large pumping plants. In fact these pumping plants hold the record and are the largest in the world. This, too, is the largest single body of land on which pumping has been attempted. On the north side of the river there are five small irrigation pumping plants, which supply water to areas varying in size from 100 acres to 2,200 acres. One other plant pumps water from a large drain ditch that flows into a swamp or pond, the surface of which is below the river level, and discharges it into one of the irrigation canals, from which it is used again for irrigation.

One peculiarity of the Gravity Unit of the project is that the general surface of the land is almost flat, so that land 10 miles from the river is in many cases practically at the river level. This is one of the reasons why the seepage problem early became a very serious one for the project.

The soils vary from a loose sand which moves readily in the wind to a comparatively heavy loam.

There are no adobes on the project, although some of the river bottoms approach this class of soil. In the earlier days before the farms had been successfully put under cultivation, the crops were blown out two or three times during a single season; often when the young plants were making good progress, a wind would come up and the movement of the sharp sandy particles along the surface would cut the young plants off at the ground level. This is particularly the condition on the northeast section of the project. Most of these places have now been successfully put into alfalfa and in a few years this crop puts enough humus in the soil to act as a binder and the difficulty is overcome.

The most interesting and extraordinary development on the Minidoka Project is the great use made of electricity in the towns and on the farms, which are so situated that they can secure electric power. Outside of the irrigation season electricity is a by-product and as the population of the towns is not sufficient to anywhere near use the capacity of the power plant when electricity is consumed for ordinary purposes, it has been possible to make low rates and to encourage the use of electricity as a substitute for coal for such purposes as heating houses and large buildings. Hundreds of homes are thus heated and all classes of people are taking advantage of this opportunity to increase the comfort of life. The consumers' installations run all the way from small one and two room shacks, using perhaps two or three kilowatts, to a large school building in which a central heating plant consuming some 600 kilowatts is used to heat a building of 30 rooms. This electricity



INTERIOR OF MINIDOKA HYDRO-ELECTRIC POWER-HOUSE
MINIDOKA PROJECT, IDAHO

ELECTRICALLY HEATED HIGH SCHOOL AT RUPERT
MINIDOKA PROJECT, IDAHO

is sold at a price of from $1 to $1.25 per kilowatt per month, which is equivalent to a small fraction of a cent per kilowatt-hour. The amount of heat required for homes varies widely with the size and construction. Many of the ordinary five or six room houses are heated at a cost of from $12 to $15 per month. Electricity at a little higher rate is sold for cooking, washing, ironing, lights, pumping and many other domestic purposes, for which it is so useful in the home and on the farm.

The Reclamation Service is in some cases also selling power to the individual consumer. Where it is feasible, however, the farmers are encouraged to form mutual companies, which take the power at some central point and distribute it to the members. In this way some hundred or more farmers are now supplied. In the towns small distributing companies have been organized for retailing the power. Cheap power has been an attraction which is bringing in manufacturing industries of various sorts. One large sugar factory has been in operation for three years at Burley, Idaho, and another is being erected between the towns of Rupert and Paul. There are several small flour mills in operation and a 300 barrel mill is now being put in at Burley. Several alfalfa meal mills are in operation. There is a large brick yard in Heyburn, an ice-plant at Rupert and many other industries. Special effort has been made by the management of the project to bring in industries which help create markets for the agricultural products. These efforts have been rewarded with success, and it is believed that the present prosperity of the country is largely due to the development of home markets. At the present time there is an opening for many more industries. A movement is on foot which is expected to result in bringing in the organization of a mutual creamery at Rupert. Two mutual cheese factories have been organized, one at Acequia and one at Paul. These are doing a very good business and are unable to supply the demand for their products.

Alfalfa is still the staple crop and the crop bringing in the largest revenue. With this as a foundation it is possible to build up a large dairy industry and other industries which will result in the manufacturing of the finished product in this section.

A large amount of money is being expended at the present time for road improvements. Several hundred automobiles have been sold to the farmers during the last year. The combined result of this is to increase the facility with which the settlers get over the project and become familiar with each other and their problems. Farmers came in here a few years ago all entire strangers to each other; they are now becoming well acquainted and are therefore able to work together for their common good.

On August first the settlers will vote on taking over the operation and maintenance of the Gravity Unit of the project. There is little doubt but that they will carry the election, and if they do this will be the first of the Reclamation projects to be turned over to the farmers for operation. The Service is encouraging the farmers to take control of this part of the project, where the construction work is now practically all completed and handle it themselves.

The principal products are alfalfa, forage, grasses, rye, wheat, oats, sugar beets, potatoes, and fruits, and the principal markets are Pocatello, Idaho; Salt Lake City, Utah; Butte and Helena, Montana.

The limit of the farm units on public lands is 80 acres, and the building charges vary, being $22, $30 $40, etc., according to locality, per acre of irrigable land, payable in twenty years, without interest.

The towns and populations on the project are Rupert, 1,500; Heyburn, 300; Burley, 2,500; Ashton, 600; Paul and Marshfield, and they are reached by the Oregon Short Line and the Salt Lake and Idaho railways.

The present Project Manager is Barry Dibble, with offices at Burley, Idaho.

CHAPTER XIII

JACKSON LAKE ENLARGEMENT PROJECT
IDAHO–WYOMING

Since the passage of the Reclamation Act in 1902 several important changes have been made in it as imperative needs have arisen. No one assumed that its first provisions were perfect, or adequate to meet every contingency that might arise, hence wisdom has allowed it to be alive, elastic. The Service has had no desire to confine its energies to the building of its own bureau or department alone, merely seeking to increase its own size and power. When opportunities arose for larger, wider, greater public service its officers gladly availed themselves of the openings and went out into fuller usefulness. They are not only authorized but are required, upon the proper showing, to give assistance to outside irrigation systems, provided, however, the storage dams and reservoirs constructed and created are owned by the Government, so that they ultimately come into the possession of the actual farmers. In other words the Service will construct great irrigation systems for corporations or private capital, but these corporations cannot own the works so constructed, the ultimate aim being their complete ownership by the farmers whose lands are being irrigated by them.

The Jackson Lake Enlargement is a work of this character. Certain companies were irrigating large areas of land in Idaho. Their supply of water became insufficient. To remedy this need the companies—the Kuhn Irrigation & Canal Company and the Twin Falls Canal Company—entered into an agreement with the United States whereby more water could be secured. These companies advanced all the money required for the accomplishment of the work, and the title and control remain in the hands of the United States.

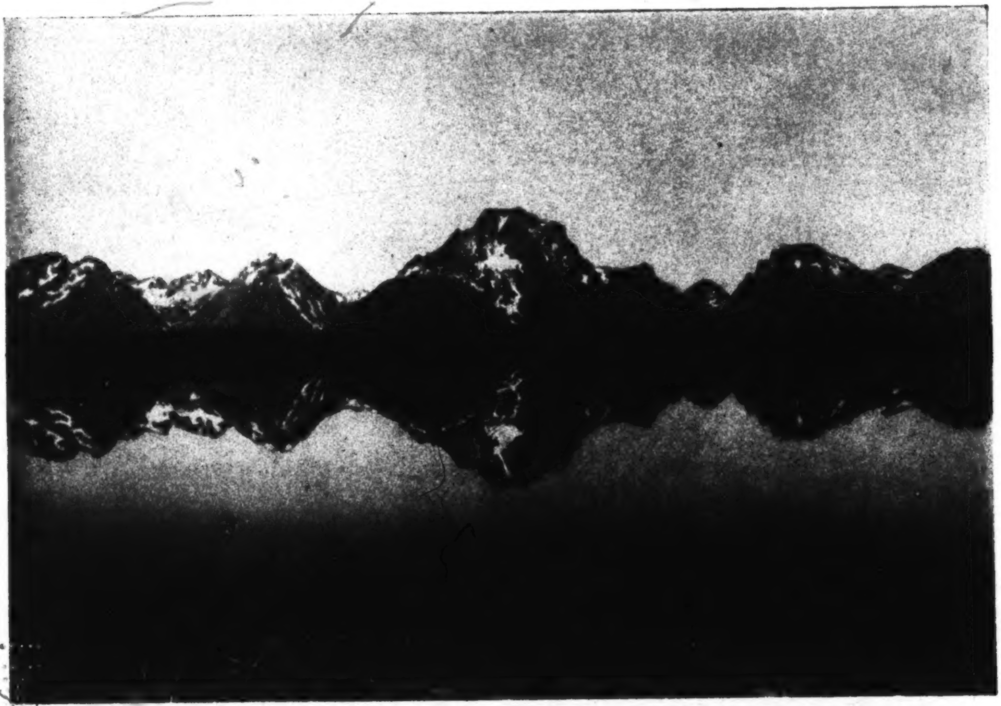
Jackson Lake, Wyoming, was already being used for storage purposes, and careful study by the Service engineers revealed that the dam could be raised and the storage capacity correspondingly enlarged.

This lake is located in the northwestern corner of Wyoming, 23 miles east of the Idaho-Wyoming line, 20 miles south of the south boundary of the Yellowstone National Park, on the South Fork of the Snake River, and the dam is placed at Moran, at the outlet of Jackson Lake. It is about 69 miles from Ashton, and 48 miles from Victor, Idaho, both on the Oregon Short Line Railroad.

The history of Jackson Lake as a reservoir dates back to 1902 and 1903, when the first surveys were made of it by the Service in connection with the Minidoka Project and a gauging station at the outlet was established on September 1, 1903. During 1905, 1906 and 1907, a temporary timber-framed dam was constructed at the outlet to provide about 200,000 acre-feet of storage for the Minidoka Project until the duty of water could be determined, and the storage requirements ascertained. In 1909 further surveys and investigations were made for a reservoir that would represent the ultimate development of local water resources, as several of the Carey Act companies in southern Idaho had expressed a desire to obtain storage at this point. In due time proper legislation was enacted to permit the United States to enter into a contract with these companies for the construction of a high dam.

Later, in July, 1913, the Kuhn Irrigation & Canal Company was found to be in financial trouble and could not keep its part of the contract. But the farmers were dependent upon the enlarged water supply, hence matters were so adjusted that work progressed. The enlargement is now completed. The original dam, constructed in 1911, is entirely enveloped in a new dam, raising the maximum water surface seventeen feet, and increasing its storage capacity from 380,000 acre-feet to 789,000 acre-feet.

The Engineer in charge of the work was F. A. Banks, with office at Moran, Wyoming.



JACKSON LAKE RESERVOIR AND TETON MOUNTAINS—MT. MORAN IN CENTER
MINIDOKA PROJECT, IDAHO

CHAPTER XIV

ON THE LOWER YELLOWSTONE. THE HUNTLEY PROJECT, MONTANA

The sound of the name Yellowstone brings a thrill to the heart of every cultured traveller. Even if he has not seen the spouting geysers, the canyon of gorgeous colours and waterfalls, the richly coloured pools, the friendly bears and deer, the mud volcanoes, sulphur mountain, obsidian cliff, and the glorious terraced pools, he has read and dreamed of their attractions and allurements.

But the Yellowstone River lives in the hearts of men not only because its waters make the thunderous music of tuneful cataracts, and sing to scintillating glory of brilliant colour down the canyon of rapids and cascades. They also give life and nourishment to fertile fields, productive gardens, and fruitful orchards and thus minister to the physical and financial well-being of man. The region chosen for the diversion of the waters of the Yellowstone is a historic one. It was trodden early by the band of brave explorers led by Lewis and Clark on their great Oregon Exploration, Captain Clark having returned home by the Yellowstone River. Indeed his name is carved upon a noted landmark of the region—Pompey's Pillar—with the date July 25, 1806.

Not far away to the southeast is Custer's memorable Battleground, where the flaxen-haired general went down to brave death with his gallant soldiers and covered themselves with imperishable glory and a nation's tears.

The old and original name of Huntley—which is now borne by the project—was Baker's Battleground. The whole region is one of romance. Following the explorers came the Indian traders, trappers and pioneers from the Missouri River. In the early days it was a region of Indians, buffalo and fur-bearing animals. Crows, Sioux and other warlike tribes roamed the natural pastures, killed what buffalo they needed, and fished in the well-stocked streams. Then came the fur-traders, later the mining prospectors, and, in the early 'sixties, a number of Southerners who refused to fight against the Union. Finding the country a well-watered, smooth and fertile one, many of these new-comers soon turned to agriculture and thus laid the foundation for the present modern development.

The lands under the Huntley Project are situated in the Yellowstone Valley and extend in a compact body from Huntley to Bull Mountain Station on the Northern Pacific Railway, 40 miles east of Billings, Montana. They lie south of the Yellowstone River at an altitude of about three thousand feet above sea level. The tract comprised about 33,000 acres of what was formerly part of the Crow Indian Reservation and is included within the ceded strip which is open to settlement under the provisions of the act of Congress approved April 27, 1904.

The irrigable lands slope gently toward the Yellowstone River. They are in general smooth, and there was little expense in putting them under irrigation. Toward the lower end of the project, however, five thousand acres are flat and alkali has accumulated. About one-half of these lands are underlain with gravel at a depth of from three to six feet, and it was thought that by using care no special trouble would be had. The remaining lands have a heavy clayey soil extending to a considerable depth, perhaps ten or fifteen feet, before gravel is encountered. The soil on the project in general varies from a heavy clay to a light sandy loam. In most places there is a good growth of grass, while occasionally there is a heavy growth of sage-brush. The alkali lands are distinguished by greasewood, salt grass and similar plants. Along the river there is in most places a heavy growth of cottonwood trees. This growth furnishes considerable timber for fire-wood, fences and general purposes. South of the irrigable land the country rises gradually to the high divide between the Yellowstone and the Big Horn Rivers. This country is covered with grass and suitable for the grazing of stock. Across the river from the Huntley Project, at the western end, is an irrigated bench which is being developed under the Carey Act. Lower down the river the country slopes back into a series of rough, broken hills, suitable for grazing and having more or less pine and cedar trees.

Water for the irrigation of this tract is taken from the Yellowstone River. Rising in the rugged, snow-capped peaks of the Yellowstone National Park, this river flows into the great natural reservoir, Yellowstone Lake, which conserves the water and regulates its flow. In addition to this, large national forests through which the river passes hold back the melting snows and maintain the discharge of water throughout the summer. The Yellowstone River above Huntley has a drainage area of about 11,180 square miles. The approximate maximum discharge of the river at this point during the high water period, which is usually in June, is 30,000 cubic feet per second, and at the end of the irrigation season in October the discharge is approximately 5,000 cubic feet per second.

Unimproved lands with water right under the Carey Act across the river from the Huntley Project sold in 1909 for $50 per acre. Improved lands in this immediate vicinity sold from $100 per acre up. A brief investigation and estimate was made of the Huntley Project and it was found that the cost of constructing the canal with complete distributing and drainage system would not exceed $30 per acre. There was a ready home market for all the farm products that could be raised, as there were from five million to six million dollars' worth of farm products shipped into Montana every year. It has been demonstrated that all the crops which could be grown in the same latitude anywhere could be grown here.

The climate of the Yellowstone Valley is especially favourable. During the growing season the days are long and there is a preponderance of sunshine. The highest temperature is about 100 degrees Fahr., and during the winter months the mercury seldom drops below zero and then only for a few days at a time. The dry season, coming as it does at harvest time, is also an aid to agriculture. Here, then, was found 33,000 acres of fine agricultural land capable of supporting six hundred families that really was not supporting six. There was an abundance of water, a ready market and good climate.

Two transcontinental railroads traversed the entire length of the tract, the Northern Pacific and the Chicago, Burlington and Quincy. The land could be reclaimed at a cost not to exceed $34 per acre, including a payment of $4 per acre to the Crow Indians who owned the land. Irrigated lands farther up the valley were selling for from $100 per acre up. If this tract had not been included in the Crow Reservation, it would have been settled years previous to this.

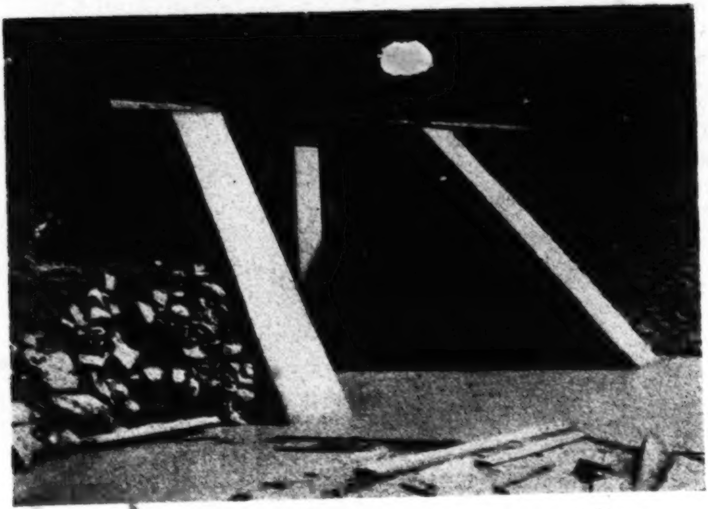
These facts had been carefully considered by the engineers of the Reclamation Service and within a few days after the passage of the act of April 27, 1904, providing for the investigation of feasible irrigation projects on the ceded strip of the Crow Indian Reservation in Montana, an engineer was directed to make a reconnaissance, and on April 18, 1905, the construction of the Huntley Project was authorized.

The Crow Indian Reservation was established by order of President Grant, January 31, 1894, and all the lands of the project were embraced within its confines, hence were not subject to homestead entry and development. The act of April 29, 1904, provided for the payment to the Crows of $1,150,000 for the lands. The Indians were to have a reasonable time within which to elect whether to remain there or to have their improvements appraised and sold and to remove to the diminished reservation. After the completion of allotments to the Indians, the residue of the ceded lands was to be subject to withdrawal and disposition under the Reclamation Act, provided, however, that if the lands withdrawn under the Reclamation Act were not disposed of within five years, all the lands were to be disposed of as other lands provided for in the act.

The water supply is obtained from the Yellowstone River, which at Huntley, Montana, has a drainage basin of 12,000 square miles. The run-off during the period 1908 to 1914, inclusive, varied from 1,700 second-feet to 47,900 second-feet, the minimum occurring during the winter months and the maximum during the summer months. The run-off for the summer 1914 was unusually low. During the five years (1908-1913) the run-off in acre-feet per annum has been: maximum, 7,391,600; minimum, 5,068,000; mean, 6,145,520.

The supply of water for the project is diverted from the river about three miles west of Huntley. At that point the diversions are regulated by substantially built concrete headgates which remain wide open during the irrigation season. The water diversions to the project are regulated by a sluiceway about two miles below the headgates and from that point the entire flow in the main canal can be diverted to the river at any time. The river flow during the season of 1914 was very low and at one time all the water that could be diverted was used for irrigation purposes.

After careful study of the region by the engineers of the Reclamation Service in 1904 the location of the intake and the course of the canal were decided upon. Three tunnels were found necessary in order not to interfere with the Northern Pacific Railway line. These were to be 9.2 feet wide and



Headgate, Showing Gate Stands, Yellowstone River
Huntley Project, Montana

Direct Pumping Plant
Huntley Project, Montana

9 feet high at the centre of the arch, and were to be lined with concrete from 6 to 12 inches thick.

Immediately upon the completion of location and cross-sectioning of the main canal, the work of subdividing the irrigable land was commenced and all section lines were traced and 16th corners set. At the same time a careful study of the resources and conditions affecting the farmers of the Yellowstone Valley was made before deciding upon the 40-acre farm unit policy. A house to house canvass of the irrigated lands near Billings showed that a good living was being made on 40 acres of land. The building of the beet sugar factory at Billings and the establishment of a creamery at that point, together with the general development of this part of the State, were found reasons why a small farm unit should be adopted. In laying out the farm units on this project, the policy has been to give each settler about 40 acres of irrigable land and to include with the irrigable land such pasture land or woodland as could be found adjacent. The farm units therefore contained from 40 to 160 acres of land, of which 40 or more acres are classed as irrigable. In many cases the units are made up of fractional lots, thus bringing the total of some farm units up to 60 or 70 acres, a large number of these units lying along the main canal and along the Yellowstone River or where broken land occurred.

Owing to the fact that the lands under the Huntley Project are flat and in some cases impregnated with alkali and also owing to the small farm unit, it was decided best that the Government construct the lateral system so as to deliver water to the high point of each farm unit and to lay out a system of wastewater ditches to assist in keeping the alkaline lands from becoming water-logged and unfit for cultivation. One hundred and sixty miles of lateral ditches and 65 miles of waste water ditches were required to develop about 29,000 acres of irrigable land.

The intake is located in the Yellowstone River about 2½ miles west of Huntley. The headworks consist of a reinforced concrete structure provided with two steel gates, each 5 feet by 7 feet and arranged to divert water without the necessity of a weir. The floor elevation of the headworks is 2,996.2 feet, while the surface elevation of the river at low water is 3,003.5 feet.

From the headworks the water is carried through Tunnel No. 1, which is 724 feet long; thence through a rock cut to Tunnel No. 2, 1,545 feet long; thence through open cut and slough to Tunnel No. 3, 385 feet long. The three tunnels have a total length of 2,654 feet.

About a mile east of Ballantine the main canal drops about 34 feet. It was decided to utilize the power obtained from this drop to pump water onto the adjacent bench and irrigate about three thousand acres of land. The power house is of reinforced concrete. The interior is in one room which contains the two pumping units. The units are duplicate, and each consists of a vertical turbine actuating a 20 inch centrifugal pump. Both turbine and pump are mounted on the same shaft and enclosed in a steel cylinder casing. The weights of the moving parts are carried on a water bearing, under pressure from the force pipe. An automatic alarm gives warning of any failure of this system of water lubrication.

These pumps have been in constant use without interruption and are practically automatic in their operation. No engineer or attendant is required except to inspect them occasionally and regulate the supply of water. This inspection and adjustment is made by the canal rider in charge of the district and does not interfere with his other duties, as it is required to be done only two or three times a day.

A telephone system was installed in 1906 which has been a great convenience to the settlers.

On May 21, 1907, the President issued a proclamation declaring that the lands shown on the approved farm unit plats of the Huntley Project would, on and after July 22, 1907, be open to settlement entry and disposition under the provisions of the Reclamation Act and the Act of April 27, 1904. In order that the settlement of these lands might be effected in an orderly manner, the intending settlers were required to register at the district land office at Billings, Montana, before 4:30 P. M., on June 25, 1907. A total of 5,491 registrations was made for these lands. At 9:00 A. M. the next day, in the presence of the Secretary of the Interior, the drawing was made from the registered applicants and a thousand numbers were drawn. Beginning July 22, the applicants corresponding to the first fifty numbers were allowed to file on the lands. Each day thereafter fifty persons were allowed to file until the names on the list were exhausted, and

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on August 23 the project lands were thrown open to unrestricted entry under the terms of the Reclamation Act. A charge of 25c was made upon registering.

There were hundreds of people in Billings and immediate vicinity that registered for these lands who had no intention of filing on them, but registered presumably to swell the number of registrations and see what number they would draw. Out of the first thousand names drawn there were 574 whose residence was given as Billings. A great many people came from considerable distances to register for these lands with the intention of filing, and of course a great many of the names were not drawn out among the first thousand drawn, and a great many others were so far down on the list that they returned home thinking the lands would be filed upon and they would have no chance of getting a farm. Out of the first thousand names drawn only 76 filed.

At the opening of the project there were 28,921 acres of land, containing 585 farm units, open to settlement. On January 1, 1910, there had been 352 farm units entered upon, containing 20,905 acres. Settlers largely from the middle and western states have settled on the lands and are improving them as rapidly as possible. Some very good houses and improvements are being put up on the farms. During the season of 1908 about 4,100 acres were cultivated and during the season of 1909 about 8,500 acres were under cultivation, which is about one-half the irrigable acreage which had been filed upon to that time. In 1916 the acreage cropped was 18,581 and the value of crops was $489,071 or $26.32 per acre.

On July 27, 1909, a severe hailstorm visited the project which damaged the crops to an amount estimated at $50,000. A good showing was made by most of the settlers the first season on their land, with much better results the second season.

One hundred and fifty miles of county roads have been laid out and the county has spent hundreds of dollars for grading and improving them where necessary.

Nine school houses were built during the season of 1908 and schools held in all of them. In 1916 there were eight school houses, several districts having been consolidated and graded.

A farmers' club has been organized to look after the general interests of the farmers and the marketing of the products.

Several church organizations have been started and services are held at regular intervals at six points.

Before laying out the farm units on the Huntley Project it was decided to have a town site every five or six miles on the two transcontinental railroad systems. The land having been withdrawn in proper form, it was easy to arrange this in the best manner. The two railroads involved gave their hearty co-operation and have put in switches and passing tracks at the townsites selected.

In planning for townsites in a thickly settled irrigated district, it was considered good policy to have the towns close together to insure shipping facilities and to give a chance for schools and supply points close to the farms. In connection with several of the townsites, 1, 2, and 3 acre tracts have been laid off, which are suitable for a home with garden, orchard and cow lot, but which are close to the business of the town. In accordance with this policy the townsites of Huntley, Worden, Osborn, Ballantine, Newton, Anita, Pompey's Pillar and Bull Mountain were laid out. Huntley and Osborn are on both railroads; Ballantine and Anita on the Chicago, Burlington and Quincy Railway, and the remaining townsites on the Northern Pacific Railway. All the townsites are in Yellowstone County, Montana.

The townsites were surveyed during the spring of 1907, and stone monuments were set at the intersection of the principal streets.

It was decided to appraise only a portion of each site because there would be at first only a limited demand for lots, for whenever at any particular townsite the growth was such that there was a demand for more lots, another appraisement could be made in accordance with the demonstrated and prospective value of the remaining lots at that time.

Huntley, Ballantine, Worden and Pompey's Pillar have been the most progressive towns on the project. Their citizens are investing their money in building permanent homes.

There is a private irrigation project owned by T. P. Walters, on the Huntley Project. It irrigates the farms of T. P. Walters (330 acres), E. H. Gagnon (70 acres) and F. L. Skillman (170 acres). It is designed to divert about 15 second-feet of water from the Yellowstone River.

Taken as a whole the Huntley Project may be regarded as a most successful one. The crops have been good. The principal crops raised in 1915 were sugar beets, alfalfa, wheat and oats, in the order named. The four crops represent about 89 per cent. of the total cropped area for the year, and they returned 90 per cent. of the total estimated crop value. There were 5,402 acres of land seeded to sugar beets which yielded a total of 53,911 tons, valued at $319,153; 6,038 acres of alfalfa yielded 15,010 tons, valued at $86,458; 2,869 acres of wheat yielded 56,863 bushels, valued at $49,471; 2,514 acres of oats yielded 75,319 bushels, valued at $36,906. The remainder of the cropped area was made up of barley, bluestem, beans, corn, cucumbers, hay and vegetables, all of which produced well and good returns were received. The beet crop was the largest shipment, all the beets being shipped to the Billings Sugar Factory. The contracts which the Sugar Company entered into with the growers in 1915 returned the farmers about $5.92 per ton.

The increase in stock values for the year 1914 amounted to $83,907. This increase was principally in horses, cattle and hogs. There was an increase of 342 horses, 1,077 head of cattle, and 2,589 hogs. There were two or three thousand head of sheep fed during the winter months. The value of these sheep, however, is not included in the above increase as most of the sheep were fed under contract and at the close of the feeding season were turned back to the owners. The sheep that were fed during the winter 1912–1913 in most instances brought good returns to the feeders in cash, besides increasing the fertility of the soil. The principal increase in cattle was in dairy stock. Three carloads of Holstein cattle were shipped onto the project early in the spring, and other cattle were bought locally. The farmers are gradually going more and more into the dairying and stock business. The principal markets for stock are Chicago, St. Paul, Omaha and Seattle.

At the beginning of 1914 forty-three farm units, comprising 1,700 acres of irrigable land, were open to entry. After the Second Unit of the project was thrown open this number was increased by the addition of twenty-four public farm units, comprising 981 acres of irrigable land, and of approximately nine private farms, embracing 833 acres. Thus the total number of farm units open to entry during the year amounted to sixty-seven involving 3,515 acres of irrigable land. At the close of the year fifty-two farm units were open to homestead entry, fifteen units having been filed upon.

The unentered public lands on the first unit of the project lie chiefly in the vicinity of Newton, Montana. The progress of settlement on these lands is not rapid for the reason that the soil in most instances is clay containing an abundance of alkali salts, which makes the units undesirable, and it is believed that a number of years will pass before the units are all filed upon. It has been demonstrated on similar lands that from five to six years of intensive cultivation are required to bring the land into a profitable productive state. The greater portion of this class of land has been settled upon by foreigners, who, in addition to farming their own units, contract as beet help on the better class of land, and in this way are able to make a living and finally bring their units into a productive state.

The present Project Manager is R. H. Fifield, with offices at Huntley, Montana.

CHAPTER XV

AN INTERNATIONAL PROBLEM. THE MILK RIVER PROJECT, MONTANA

There are some rather curious things to be noted on the map of the northern boundary of the United States, especially the way in which the rivers flow with reference to this boundary. In older countries, the limits of the nations were established largely by natural features, by mountain ranges or rivers; but with us the division between two great bodies of English-speaking people is a straight line arbitrarily located, extending directly west, crossing plains and mountains. This typifies the arbitrary character of our political division. The plains on each side of the line are identical; Nature offers no more differences than do the ideals of the citizens thus separated from each other. Looking closely we see that some of the rivers arising in the United States flow for a time in Canada and then return. In the same way the people of one country sojourn for a time in the other and may come back or possibly remain.

There is one river, the Milk, which is particularly notable, not because of its size but rather because of its insignificance as regards volume. Its tributaries flow easterly along or near the border, crossing and recrossing, being partly in northern Montana or in the Canadian provinces of Alberta and Saskatchewan. It occupies in places a broad valley; for much of the year it is nearly dry but occasionally there are destructive floods. Following up along the boundary to the headwaters, we are surprised to find that these stop short just before the high mountains are reached. Unlike most streams of that part of the world, it has no connection with the waters from the snowy peaks which dominate the western horizon. Here is a very curious phenomenon—a long river occupying a broad valley and shut off from its natural source of supply.

The valley with its fertile lands early attracted settlement, and the pioneers soon built little irrigating canals, increasing these until the capacities have exceeded the low water flow of Milk River. The man higher up the stream, although second in right, had the first opportunity of getting the coveted water. Controversies arose and the further development was retarded, more money being spent in litigation than in actual irrigation. All of the time the people interested had their thoughts fixed on these high mountains to the west with their abundant supply, and they began to ask why they could not get their portion of the abundance from the snowy fields to the west. How did it happen that their river did not obtain its proper share?

The reason for the scanty supply in Milk River is quite evident to the geologist. In comparatively recent times, as the age of the earth goes, a great ice sheet or series of ice sheets covered this land, pushed southward the rocks, gravel, sands and clays; on retreating it left behind a great unassorted mass of dirt which encumbered the surface of the ground and obliterated the former water courses. One of these great masses of materials which had come from the north was left lodged as a series of hills or a ridge directly east of and in front of the main Rocky Mountain range, so that the streams flowing easterly from the mountains instead of continuing down the gentle slope of the great plains were diverted and turned abruptly towards the north, flowing finally into Hudson Bay instead of into the Mississippi River drainage.

Seeing the conditions resulting from this glacial action, the geologist and the engineer were asked whether man could repair the damages done by the ice sheet and cut through this range of hills, restoring to the plains' streams the headwaters which in past geologic ages probably belonged to them. From the engineering standpoint this was comparatively easy though expensive. A greater obstacle was found in the artificial or political conditions, because the boundary was drawn in such a way as to make it impossible for either Canada or the United States to utilize the natural advantages without the consent of the other. It was physically possible to take the streams which flow easterly from the Rocky Mountains and form the St. Mary and divert them easterly through a canal which, heading in the United States, would swing around into Canada. It was also possible at somewhat greater expense to build such a canal in the United States and drop the waters taken from the St. Mary River into the head of Milk River, but this water would then flow into Canada before coming back into the United States. It was also possible at still greater expense to continue the canal wholly in the United States and drop the water in the streams which would keep south of the boundary.

All of these conditions formed the subject of much discussion. It was assumed that if the United States built a canal from St. Mary to Milk River, the Canadians must permit the water to come down the natural channel and that they could not prevent it from coming back into the United States for use in the Lower Milk River Valley. Their reply to this was the actual construction of a canal from Milk River in Canada which could take and keep in Canada any waters which might be diverted by the United States into the head of Milk River. Through many years surveys, conferences, and discussions were had. In these the engineers of the Reclamation Service called upon by the settlers along the Milk River were active, not only in making surveys and estimates of various alternative projects, but in preparing drafts of agreement with the Canadians. Finally, it was agreed that the United States would take its chances and begin construction of distributing works in the Lower Milk River Valley to handle the water which was available, in the hopes that a satisfactory solution might be had of the international problem.

The Ambassador from Great Britain, the Hon. James Bryce, took a large interest in this matter, and partly through his efforts to promote amicable relations, a treaty was negotiated "to prevent disputes regarding the use of boundary waters and to settle all questions which are now pending between the United States and the Dominion of Canada." This was signed on January 11, 1909, and marked the culmination of many years of discussion and negotiations. Meantime, as before stated, construction on various features of the project had been begun so that these had fairly well progressed before the treaty was signed.

The second difficulty to be overcome was the matter of sufficient funds for prosecution of the work. The estimated cost of the work was about seven million dollars and the million dollars set aside in 1905 was for preliminaries. In 1910, Congress set aside the money necessary to carry on a portion of the work. The last obstacles were the adjustment of water appropriations in the river so as to settle the ownership of the waters and as fully fifty per cent. of the lands were privately owned, it was necessary to bind them to stand security for the expenditures the Government contemplated making. It was necessary to make sure that the water of Milk River, including natural runoff and that diverted from St. Mary Lakes, should be sufficient to supply those who had heretofore appropriated water, as well as for the government canals. Private rights were definitely stated in a vested water-right contract, which fixed the amount of appropriations and the lands to which they attached, and the United States was assured of a sufficient supply for its work. Then it was necessary for the lands in private ownership in the Valley to be bound to take water and return payments for construction, operation and maintenance. These matters were finally adjusted and the Secretary of the Interior approved the construction of the project in 1912.

It must be said that a certain amount of impa-

Fort Belknap Dam, looking upstream
Milk River Valley, Montana

tience was naturally exhibited by inhabitants of the Valley because of the length of time, 1902 to 1912, which elapsed before the larger work of the project began. But in view of the difficulties involved, it can be seen that the work could not have proceeded more rapidly.

While the difficulties were being adjusted, some work on the project proceeded, notably the construction of a dam in the Milk River near Dodson, Montana, and the completion of the first unit of the project, with canals for watering 7,800 acres of land.

The greater activity on the project began in 1912. At the present time the system has been carried to a point where one-fourth of the 220,000 acres of land in the project is under completed canals. A second large concrete dam is completed, near Vandalia, Montana. Until 1916 the system was dependent upon the flood waters of Milk River, but work on the St. Mary Canal is completed, and these mountain waters, travelling 500 miles through natural and artificial channels, will bring a perpetual stream of water and a continuous lease of prosperity to the Valley.

The Dodson Diversion Dam is located 46 miles below the proposed Chinook diversion and 3 miles west of Dodson. The dam is a rock-filled timber-crib, 19 feet high and 319 feet long, the downstream face of which is composed of 10-inch timbers protected by railroad rails. The north abutment is of similar structure, while that of the south side is of reinforced concrete. On top of the dam concrete piers are built for a movable crest which will add six feet to the height of the dam when completed.

In connection with the construction of this dam it was necessary to raise the tracks of the Great Northern Railway for a distance of 4 miles and to protect, by riprapping, the embankment from erosion. In addition, 2,425 acres of private and Indian lands were purchased for flowage rights.

The Dodson South Canal heads here with a capacity of 900 second-feet. It ends at Nelson Reservoir, 44 miles away, with a capacity of 500 second-feet, furnishing on the way water for the irrigation of 42,500 acres, of which 26,000 are under its branch canals, the Ashfield and Bowdoin. The headworks consist of a concrete structure with 15 openings 4 feet by 5 feet. The principal features of this system which have been completed are the Peoples Creek dikes and channels for the diversion of that creek, so as to discharge above Dodson Dam, and also to protect private irrigation plants on the Fort Belknap Indian Reservation; the Point of Rocks equalizing reservoir, of 830 acre-feet capacity; the wasteway at, and siphon across, Alkali Creek, which consists of three lines of reinforced concrete pipe 7.5 feet in diameter; the headworks of Bowdoin Canal; the spillway into Lake Bowdoin; and the canal-, lateral-, and waste-water systems for the irrigation of 15,000 acres.

A portion of the Main Canal was excavated in 1908 and 1909 under the co-operative plan of contract between the Service and the Water Users' Association. The remainder of the excavation for the first nine miles was done by small contracts and a portion by the Service. The latter also built the structures and laterals for the irrigation of 7,800 acres. The balance of the work on this canal system was built by private contracts.

The Dodson North Canal heads at Dodson Dam with a capacity of 200 second-feet, and in a length of 29 miles irrigates 12,000 acres on the south side of the Milk River between Dodson and a point five miles below Malta. The principal features of this canal-system which have been built are the concrete headworks, which include four steel gates 4 by 4 feet in size; the siphon across Exeter Creek, which is a reinforced concrete pipe 5 feet 4 inches in diameter; and the canal-, lateral-, and waste-water systems for the irrigation of the land.

Nelson Reservoir, located about 15 miles northeast from Malta, is a natural basin, the storage capacity of which is increased by building dams across depressions in the rim. At present these dams secure a capacity of 27,000 acre-feet, but as required they will be enlarged and raised by successive stages to give an ultimate capacity of 132,000 acre-feet. The reservoir is fed by Dodson South Canal, and the stored water will be used for the irrigation of about 50,000 acres under the Nelson Reservoir North and South Canals, and, if required, for lands under the Vandalia South Canal, the stored water to be discharged into Milk River down a concrete pipe-drop and again diverted at Vandalia Dam.

Nelson Reservoir South Canal, with a capacity of 260 second-feet, heads in Nelson Reservoir and will irrigate 22,000 acres of land in Beaver Creek Valley, near Ashfield, Saco, Beaverton and Hinsdale.

The Vandalia Diversion Dam is 66 miles below the Dodson diversion. It consists of a reinforced concrete main overflow dam, with fixed crest, and an automatic movable crest, by which the water can be raised an additional 6 feet. Two bridge piers, which support steel bridges for the movable crest, divide the overflow of this dam into three 110-foot lengths. The abutments are reinforced retaining walls having a maximum height of 51 feet. The entire structure is supported on piles and protected at the lower and upper edges by rows of sheet-piling. Flanking the dam to the north there is an auxiliary spillway 4 feet high and 1,200 feet long. This spillway is also built of reinforced concrete.

The Vandalia South Canal heads at Vandalia diversion with a capacity of 300 second-feet, and irrigates 22,540 acres of land on the south side of Milk River between Vandalia and a point opposite Nashua. The headgates are in the south abutment. The principal features which have been built are the metal flumes, railway culverts, concrete-lined sections at Vandalia Point, the reinforced concrete siphons across Antelope, Brazil, and Willow Creeks, and the canal-, lateral-, and waste-water systems for irrigation.

St. Mary's Lake is to be enlarged and improved to an area of 6,910 acres and a capacity of 124,000 acre-feet. The dam is an earth fill, with a maximum height of 30 feet, and a length of crest of 2,000 feet. The length of the spillway is 500 feet, and its elevation 20 feet above the stream bed. The canal is 29 miles long, with an ultimate capacity of 850 second-feet, and is to carry the water of St. Mary River across the divide to the headwaters of Milk River.

The Sherburne Lakes Dam is an earthen embankment, 83 feet high and 925 feet long. A concrete-lined spillway channel located at the north end of the dam has a capacity of 8,000 second-feet, with a free-board of 9 feet on the dam.

Reclamation makes possible a great future for the valley of the Milk River. Realization will depend upon the use the people make of the possibilities. Formerly the region was thought forever doomed to mediocre production because of dearth of water. Settlements were scattering and small, as they always are in a range country. The towns were about as wild and woolly as the country. Most of their trade depended on the cattle ranches and their times of principal life and activity were the cattle shipping days, when cowboys owned the streets and raised mighty disturbances. But a change has gradually come about, and the opening of reclamation work altered things still more remarkably. Ditch contractors have imported hundreds of labourers and the results of the activity are shared by merchants, hotel-men and business of every sort.

However, the present impetus given to trade is of small importance beside the permanent prosperity this reclamation may bring to the Valley. Where formerly production was uncertain, in the future few failures on the Valley's irrigated lands need occur. Business and industry that have been established can depend on a steady growth, while in the past they were subject to disappointing fluctuations due to uncertainty of returns and markets. Such uncertainty stunted industrial growth and kept it confined to a few lines. It retarded the increase in population, in prosperity and in the necessaries and luxuries that rightfully belong to people of the present day. But the future should hold greater possibilities. The population will increase and the new-comers will be of the best class. Agricultural production will expand steadily, money will come into the valley in an increasing amount and the facilities for enlarging the sphere of life and enhancing the pleasure of existence will multiply in number.

In the past the principal agricultural products of the Milk River Valley have been wild hay and some alfalfa, grain and vegetables. These were produced mostly for the local markets. With the advent of the government canals, and because of their cost and the increasing value of land, it is hardly probable that the raising of wild hay and grains will be economically feasible after a few years, for the returns from alfalfa, vegetables and sugar beets, and the raising of cattle and hogs will yield the best returns. The production of sugar beets and the manufacture of sugar will become a lucrative industry in the Valley. Some very good crops of this plant have already been had and the yield has been good, with a high percentage of sugar.

The Milk River Valley offers excellent opportunity for persons of industry, determination and some capital. Lands are cheap and can be obtained on advantageous terms. It must not be thought, however, that wealth awaits the settler with no financial backing and without hard labour. Irrigation farming involves a greater outlay of money and effort than other agriculture, but on the average the returns should be commensurately greater. The land must be worked and levelled, farm laterals must be dug, and in the application of water to the soil care, vigilance and labour are necessary. All this involves expense.

The settler coming into the Valley should be able to erect necessary buildings, plough and level the land and prepare it for irrigation. He will have to be able to meet any payments necessary on the purchase price of the land. If his land is under constructed canal and water is available, he may obtain water until the project is declared open, on a rental basis of $1 per acre-foot. For this latter reason the present is a very advantageous time to obtain land under canals, because the settler can get irrigation water in quantity desired and it will be some time before payments on the building charges begin. He may therefore have time to get his farm and finances established before the greater expense begins. The building charge will be divided into twenty annual instalments, payable without interest, so for the ordinarily prosperous farmer, these payments, together with the annual operation and maintenance charges, will not be a great burden.

The present Project Manager for the St. Mary's Storage unit is R. M. Snell, with office at Browning, Montana, while the Project Manager of the Milk River Project as a whole is Geo. E. Stratton, with office at Malta, Montana.

CHAPTER XVI

IN THE LAND OF THE RIVER OF THE SUN. THE SUN RIVER PROJECT, MONTANA

Ever since Lewis and Clark made their memorable trip across the continent to spy out the land as far as the then unknown Oregon, the great prairies have exercised a fascination over the minds of men equalled only by the lure of the trackless and sun-scorched deserts. At the extreme northwestern boundary of this rolling prairie country, in Montana, long, gently sloping plateaus, traversed by streams that have relatively wide valleys, rise by successive benches until they terminate in rolling glacial hills and hollows at the foot of the Continental Divide. A distinctive feature of these plateaus is that their summits appear as isolated buttes or long irregular ridges, which are eroded remnants of other and higher benches which now have entirely disappeared.

Located between the summit of the Lewis Range of the Rocky Mountains on the west, the Dearborn and Missouri rivers on the south and Teton River on the north, extending easterly as far as Fort Benton, in the northern portion, and Ulm Station on the Montana Central Railway in the southern portion, is the Sun River Project. It covers, approximately, 1,500,000 acres, excluding the mountainous portion, the greater part comprising rolling prairie country and benches of uniform slope. One of these, Greenfields bench, is a practically unbroken stretch of 70,000 acres.

The river bottom lands are mostly farmed under small irrigation systems constructed by the ranchers. A few larger systems, covering from 3,000 to 25,000 acres, have been in operation for some time.

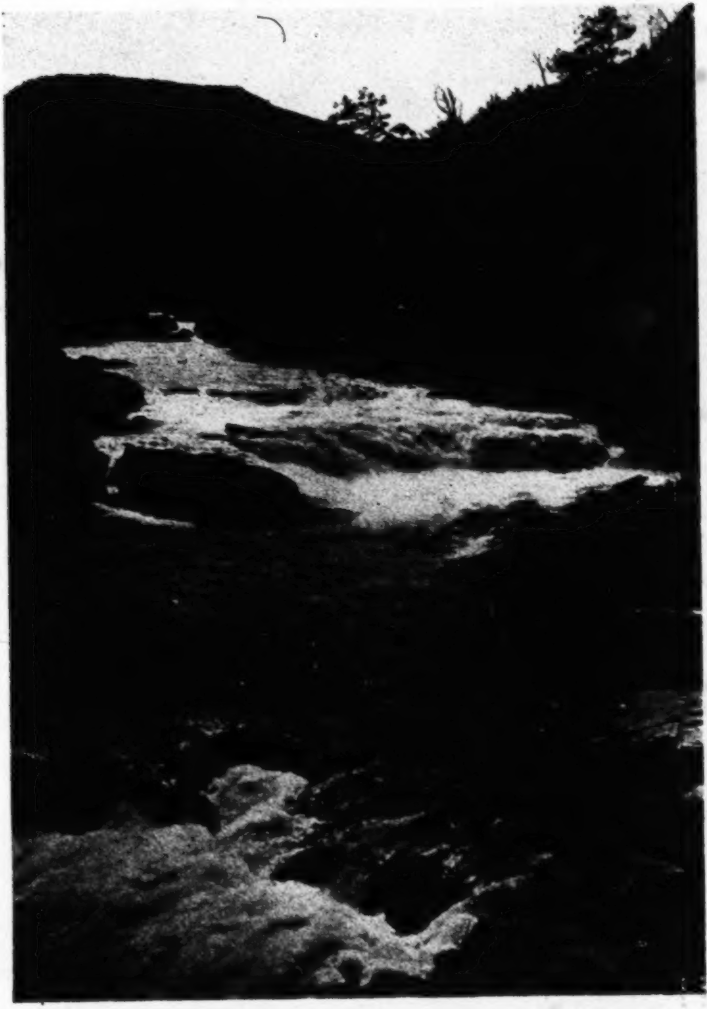
Rising on the Continental Divide the Sun River gathers water almost sufficient for the irrigation of this entire area, a princely domain vast enough to quicken the pulses of hundreds of men to the possibilities of the independent life of the farmer or rancher. The Sun River flows southeasterly to its confluence with the South Fork, thence due east, emptying into Missouri River at Great Falls. Deep Creek, the south fork of the Teton, is also utilized. The watershed of Sun River and Deep Creek comprises 1,140 square miles of mountainous country, the altitude varying from 4,500 to 9,000. This is covered, to greater or less extent, by coniferous forests which serve as natural reservoirs, regulating the run-off of the district. The numerous streams of this drainage gather a large amount of water from the melting snow, which will be stored in large reservoirs.

The average annual run-off of the watershed area is estimated at 700,000 acre-feet. The rainfall of the irrigable area averages twelve inches, the greater part of which falls during May and June.

The present approved plan of construction of the project contemplates the irrigation of about 16,000 acres of land largely in the abandoned Fort Shaw Military Reservation in Sun River Valley by direct diversion from Sun River into the Fort Shaw Canal, and the irrigation of about 100,000 acres of bench land on the north side of Sun River by the diversion of the waters of the North Fork of Sun River through the Pishkun Supply and Sun River Slope Canals.

The Fort Shaw Canal was completed in 1908 and the system has been operated each year since 1909. Works are at present under construction for the irrigation of 25,000 acres on the Greenfields Bench north of Sun River. The main features of the works required for the irrigation of the above-mentioned 25,000 acres are the Sun River Diversion Dam, 132 ft. in height, the Pishkun Supply Canal, 12 miles long, with three concrete lined tunnels 700 to 2,300 ft. long, a wood stave pipe crossing of Sun River, and concrete pipe drops into Arnold Coulee and Pishkun Reservoir; the Sun River Slope Canal 34 miles long with 9,000 ft. of concrete lined canal, and the two high concrete pipe drops into Big Coulee; and the Distribution System delivering water direct to the farms. The Sun River Diversion Dam, the main canals with their tunnels and other structures and the pipe crossing of Sun River are practically completed.

Further development of the 100,000 acres on the north side of Sun River contemplates the storage of waters of the North Fork of Sun River by a masonry dam on the stream itself. Several sites are available and investigations are now being conducted to determine the most feasible location for the dam. The surplus waters of Willow Creek are now stored by an earth-fill dam on the creek forming a reservoir



Site of Diversion Dam, Sun River Canyon, August, 1907
Sun River Project, Montana

of 16,700 acre-feet capacity, which is available for supplying water to either the Fort Shaw Unit or prior rights on Sun River.

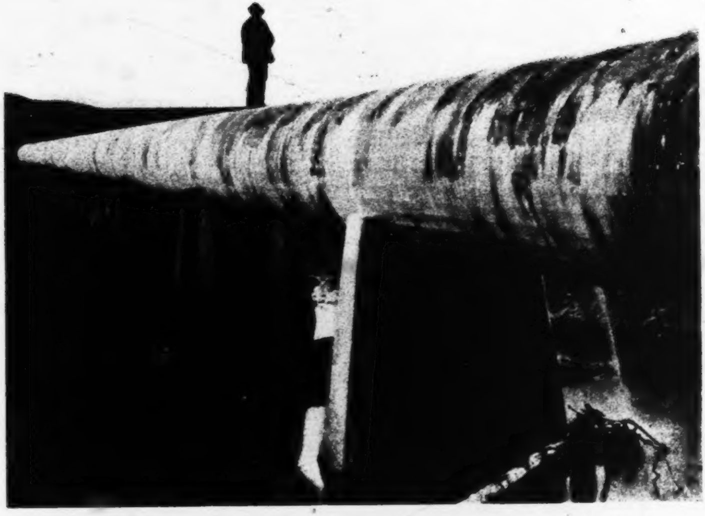
The project is traversed by three lines of the Great Northern Railway, already in operation, and by one line of the Chicago, Milwaukee and St. Paul Railway, now under construction. One line of the Great Northern runs northerly and southerly through the eastern end of the project and will be a part of a main through line from Texas to Spokane and Pacific Coast points. A second line of the Great Northern runs through the Sun River Valley from Great Falls to the western end of the project. The third Great Northern line branches from the first in the east central part of the project and runs northwesterly to Choteau on the northern boundary. The line of the Chicago, Milwaukee and St. Paul Railway runs from Great Falls northwesterly.

The elevation of the lands embraced within the project is from 3,500 to 4,000 feet above sea level, with an average elevation of about 3,700 feet. The temperature varies from 40° below zero to 100° Fahr. above. The extreme low temperatures are unusual and when they do occur ordinarily continue for a short time only. The dry atmosphere renders extremes in temperature much less disagreeable than less extreme temperatures in the humid regions. The prevailing winds are from the southwest, which tend to modify the severity of the winters. The average rainfall is about 11 inches, a large portion of which occurs usually during the months of April, May and June.

The climate of Montana, contrary to popular eastern impression, is milder than portrayed. The prevalence of the chinook wind makes the winter months compare favourably with states further south. In past years, before the encroachment of the farmer, stock ranged in the open the entire season without care or feed other than the natural buffalo-grass which cures on the stem. Of course, this method of caring for stock is to be condemned but shows the exceedingly favourable climatic conditions that make such a method possible. The snowfall is light and does not lie on the ground any length of time, being taken off by the chinook winds.

A natural growth of short buffalo- and gramma-grass and a wheat-grass locally called "blue-joint" covers the entire range. This furnished, in the past, practically the only feed that made Montana range steers the most desirable on the eastern market. A fair showing, during the last few years, has been made on this soil without irrigation, some farmers getting twenty-eight bushels of wheat and fifty bushels of oats, by careful conservation of the precipitation, but owing to the very light rainfall during long periods, this method meets with only indifferent success. Farmers coming from the eastern states, where twenty bushels of wheat per acre is a good yield, are incredulous when told of a yield more than double that quantity.

The commercially profitable products that can be grown on the project comprise practically all of the northern grown grains, grasses, fruits and vegetables. A few of the less hardy fruits and vegetables require special care, which necessarily excludes them from the profitable list, but as better methods



Simm's Creek Pressure Pipe, Fort Shaw Unit
Sun River Project, Montana

Method of Reinforcement of Simm's Creek Pipe
Sun River Project, Montana

of cultivation are discovered, these will also be profitably added to the list.

Alfalfa is highly successful, as are also the grains,—wheat, oats, barley, rye, etc. Fattening of cattle, sheep and hogs on alfalfa with grain is becoming a large factor in the development of this region, as good prices prevail in the local market for meatstuffs.

Sugar beets produce an average of twenty tons per acre. Samples were taken from ten patches of beets which were sent to the Billings Sugar Company, Billings, Montana, for analysis. The tests showed an average of 17.7 per cent. of sugar and 86.2 per cent. of purity. The Amalgamated Sugar Company of Ogden, Utah, made a careful inspection of the lands of the project, soon after work began and gave assurance that it would ultimately support seven sugar factories.

The small fruits, such as strawberries, currants, gooseberries, and raspberries, are now successfully grown in this immediate vicinity, and these grow wild in the valley as well as huckleberries, sarviceberries, and wild cherries. Tame cherries and crabapples do well, and enough is known of growing standard varieties of apples to warrant the assertion that they will be a success.

The largest market, close to the project, is Great Falls, a city of probably 15,000 people. The big smelters of the Boston & Montana Company are located here,—this with the immense water-power available, much of which is now under process of development by the construction of two large dams in the vicinity of Great Falls, gives this city a bright future and will provide a market at good prices for products grown on this project. Helena (20,000) and Butte (40,000) also provide high-priced markets contiguous to this region. Great Falls is quoted by an eastern magazine as being the highest-priced produce-market in the country. Helena is a residence city and the State capital, and Butte a money-making town, the big mines of the Amalgamated Copper Company being located there. There are excellent railway facilities for transportation to these market-centres from all parts of the project.

Owing to the dry climate, the wagon roads are hard and dry ten to eleven months in the year and the light snowfall in the winter months enables the farmer to make use of his idle period in hauling produce and supplies.

The only lands of the project open to entry at the present time are in the Fort Shaw Unit. This comprises 16,325 acres of irrigable land lying mainly in the abandoned Fort Shaw Military Reservation in the valley of Sun River. On June 9, 1917, there were 27 farm units still open to entry. These units contain from 40 to 80 acres of irrigable land, which in some cases is combined with non-irrigable land to provide pasturage for stock. The building charge on this land is $36 per acre of irrigable land.

The present Project Manager is Chas. P. Williams, with offices at Fort Shaw, Montana.

CHAPTER XVII

THE LOWER YELLOWSTONE PROJECT

MONTANA–NORTH DAKOTA

It will be recalled by those who have read the Reclamation Act as originally passed that the moneys received from the sale of public lands in the respective states were to be expended in the states from which they were received. This section of the act was later repealed, but as both Montana and North Dakota had large areas of government land which were sold after the passage of the act, the latter, indeed, leading the list for several years, it was decided to inaugurate work upon a project which should be located in these states. After extended investigations it was found to be possible to divert the waters of the Yellowstone River near the town of Glendive, Montana, into a canal on the north side of the river, and irrigate in the neighbourhood of 60,000 acres lying partly in Montana, and partly in North Dakota. The point selected for the diversion of the river is about eighteen miles below Glendive.

The diversion dam is a rock-filled pile weir decked with timber, 700 feet long and 50 feet 4 inches wide, with an average height above river-bed of about nine feet. It raises the water about four feet above natural low water into the canal. The cold climate and the flood conditions that occur rendered great care necessary in fixing upon the time when the work of building this dam should be done. A contract was let in 1906, and work began in 1907, but the difficulty of securing the proper round piles deferred the work until 1908. In April of that year 480 of the piles were driven, when high water arrested the work on May 20, and it could not be resumed until August 3. When the summer flood had subsided it was found impossible to drive the required sheet-piling, even when four-ply sheets, driven with both steam- and drop-hammer, were substituted. This necessitated a change in the plans.

Careful examination revealed that the high velocity of the flood waters of Yellowstone River, aggravated by the accumulation of drift against the piles, had caused great erosion of the river bed, and had taken out a number of the piles, leaving others barely standing upright. Upon this discovery the contractor became discouraged and refused to proceed further with the work. The Service thereupon undertook to complete it. Most of the piles driven were taken out, and, as much low-water time—highly favourable to work—had been lost, it was decided to build 62 linear feet of the dam adjacent to the south abutment, and then await the next low-water season. This was done, and while the next flood time was on, materials were assembled for the rapid prosecution of the work when the waters subsided. As soon as the subsidence occurred it was found that the river bed had again been filled with gravel.

Work began again in August, 1909, and was pushed without a moment's cessation, day or night. As fast as one shift retired another took its place.

The sheet-piling originally planned was abandoned and solid timbers of Douglas fir 10 by 10 inches, sharpened and shod, and with strips of 3 by 4 inches spiked on so as to serve for tongue and groove, were substituted. They were found to possess far greater rigidity and endurance than the piling. Wherever the ground was too hard for satisfactory penetration, a steel shape, built of riveted steel about the size of the pile, was first driven and afterwards withdrawn, and the pile driven in its place. In a few cases the ground was even too hard to allow of this being done, whereupon plain steel sheet-piling was driven.

The work was completed March 4, 1910, and soon thereafter the ice broke up and dashed down the river with its customary violence, but soundings made at low water revealed no damage to the dam. The following year, however, the ice-pounding on the apron of the dam was very severe. There were several ice-jams which broke up suddenly, thus precipitating vast quantities of ice at tremendous velocity upon the dam. Investigation showed that much of the loose stone below the dam had been moved down-stream, and that the lower row of sheet-piling, for a distance of about 500 feet, had been either cut off by the ice or seriously damaged, and that a portion of the timber deck was gone. Considerable erosion had also taken place at several points in the body of the dam, and a large amount of rock removed from the section where the deck was gone.

As it was found the steel-piling had successfully resisted the fierce pounding of the ice it was decided to replace the lost piling with steel. When this was done a full quota of rock was put into place, the deck restored and the results of another season's ice-jams awaited with confidence. The dam withstood all shocks and has ever since given satisfactory service without material damage.

The headgates for the Main Canal, eleven in number, are set in a high, massive, reinforced-concrete structure, built to an elevation above high-water mark. At Linden Creek, Burns Creek, and Fox Creek, provision had to be made for carrying the irrigation canal across these lateral streams. At Linden the creek is taken across above the canal, in a reinforced-concrete flume twelve feet wide, eight and a half feet deep, and one hundred and fifty-two feet long. At Burns, 8 miles below the heading, the creek is carried in a superstructure 100 feet wide, under which the canal water flows in two conduits, each 9 by 10½ feet. Fox Creek, 36 miles below the headworks, is the largest of the streams crossed. Here the canal is carried under the creek in a reinforced concrete inverted siphon, 225 feet long, with two barrels, or tubes, each seven feet in diameter.

Low-water period on the Yellowstone River is from August 15 to May 1 of the next year, interrupted for a short period, usually in March, when the ice breaks up and is generally accompanied by violent freshets. The regular high-water period occurs between May 15 and August 15, due to melting snow in the mountains. Ordinary low water is about 6,000 cubic feet per second, and extremely high water about 160,000, which carries large quantities of drift, mostly submerged.

HEADWORKS MAIN LOWER CANAL
LOWER YELLOWSTONE PROJECT, MONTANA-NORTH DAKOTA

The climate of the region is healthful and invigourating with good sharp winters, and warm summers, though the extremes of heat and cold are not severely felt. The air is dry and pure and there is but little humidity. Tornadoes are unknown. The annual rainfall is about 15 inches, a greater part of which occurs in May and June. The average elevation of the farming lands is 1,900 feet above sea-level. Transportation is afforded by the Missouri River and two railways, the Northern Pacific, and Great Northern, with seven railway stations on the project, the chief of which, with their populations, are as follows: Savage, 300; Sydney, 1,300; Fairview, 800, all in Montana.

In the irrigable area there is considerable variety in the soils, but deep sandy loam predominates and the main crops hitherto have been grain, forage crops and vegetables, all of which find a ready market in Minneapolis, St. Paul, and Duluth. The present status of the irrigable area open is as follows: 9,536 acres entered subject to the Reclamation Act; 445 acres open to entry; 1,514 acres of state land; 33,273 acres of private land. The limit of area of the farm unit on the government land is 80 acres. The building charges per acre is $42.50 and $45, payable in twenty years. The rental charge for 1915 was 50 cents per acre for one and a half acre-feet, with additional water at the rate of 50 cents per acre-foot. The annual operation and maintenance charge is 75 cents per acre for one acre-foot, with additional water at the rate of 50 cents per acre-foot.

The first irrigation by the Service was in the season of 1909, and in 1915 the project was reported 96 per cent. completed.

Yet, strange to say, while the water supply provided is unfailing, the works for its diversion and delivery are effective and satisfactory, the soil is productive, and the climate favourable, the agricultural results have been disappointing to the Government. This is due to the failure, or refusal, of the majority of the land owners to use the water for irrigation. The chief reason for this refusal undoubtedly is the fact that the region being only *semi*-arid, sufficient rain falls during some seasons to mature the crops, and in nearly half the years enough rains fall to secure fair crops of some kind. Many of the farmers, fully 50 per cent. are Scandinavians; they are poor and do not see the advantage irrigation would be to them. They hope for favourable rains and prefer to take the chance rather than undertake to obligate themselves to pay for the water right and the annual charge for operation and maintenance of the plant. Undoubtedly as their financial condition improves they will see that it is to their advantage to undertake the larger expenditure, as thereby their returns will not only be assured, but will be correspondingly increased.

The canal system consists of 66.3 miles of main canal, and 146.6 miles of laterals, and the lands reached stretch along the Yellowstone River from Intake, Montana, to the Missouri River. They vary in width from half a mile or less at the upper end to five miles in the Fairview district.

The Project Manager is L. H. Mitchell, with office at Savage, Montana.

CHAPTER XVIII

IN THE ROMANCE LAND OF THE PATHFINDER

THE NORTH PLATTE PROJECT, NEBRASKA-WYOMING

The country embraced within this region was probably well known earlier than almost any other portion of the West. The returning Astorians, in 1812, passed down the North Platte River, making their first winter camp of that year at the town of Bessemer, fifteen miles above Casper, and later in the vicinity of the state line between Nebraska and Wyoming—in all probability very close to the present town of Mitchell, the headquarters of the Reclamation Service. First, the intrepid hunter and trapper blazed the way, and later the fur-trading companies pushed into the North Platte Valley, and, in 1834, established a trading post on the site of the present town of old Fort Laramie, which was maintained by them until taken over by the Government in 1849, when it became one of the most prominent posts on the transcontinental route. This route was followed by the California gold seekers and by the Mormons in their migration westward. To read *The Adventures of Captain Bonneville* and *Astoria,* by Washington Irving, the discoveries of John C. Frémont, histories of Mormon emigration and the "Forty-niners," and later, of "Wild Bill" and "Buffalo Bill," reveals this valley as rich in historical interest. The discoveries of Professor Marsh, and other paleontologists, of the pre-historic horse and the great saurians make the region one of unusual interest to the student of the earth's history. On the other hand, the settler and the homebuilder passed it by and settled to the north or south, or pushed on to Utah and California. The great original California-Oregon trail, a highway 200 feet in width, now overgrown and only distinguished from the general surroundings by the difference in vegetation, stretches on mile after mile. It is marked here and there by a grave, the occupant snatched from the eager horde pressing ever west; name, age, date forgotten; whether the victim of disease or savage, unknown. But occasionally we may read something like this on a rare headstone: "Amanda, beloved consort of William Smith, born May 5, 1831, died of cholera, July 10, 1850." It requires little imagination to weave a romance around such an epitaph in such a place. Again, Irving relates, in his *Adventures of Captain Bonneville,* how a party "encamped amid high and beetling cliffs of indurated clay and sandstone, bearing the semblance of towers, churches, and fortified cities." He then recalled the melancholy circumstance from which the fantastic bluffs received their name, the story of one of an unfortunate party, a man by the name of Scott, who, after abandonment by his companions because of illness, crawled a distance of sixty miles before death put an end to his miseries, "and the wild and picturesque bluffs in the neighbourhood of his lonely grave have ever since borne his name."

The very name bestowed upon the dam—"The Pathfinder"—conjures up memories of a brave and stirring epoch in our national expansion. A fitting monument to the sturdy explorer, John Charles Frémont, a mighty figure of the romantic pioneer days, this giant structure of modern masonry rears its lofty crest on the site where the explorer was wrecked in his attempt to reach the Missouri River by water, and a wondrous valley made fertile by the magic touch of water now greets the eye where once the Indian and buffalo reigned supreme.

We thus see a revival in the locality where more than half a century ago was the best-known and most-travelled route across the continent, and after being all but forgotten is now receiving the attention which it should have received in the sixties. The South Platte Valley, 150 miles south of the great western pioneer highway, was developed through sheer force and energy of its people, while that of the North Platte has remained in an undeveloped state, though in all respects equal to the South Platte Valley. The climate, soil and flora in both valleys are almost identical.

The North Platte Project provides for the storage and diversion of the waters of the North Platte River for the irrigation of lands lying in the North Platte Valley in eastern Wyoming and western Nebraska. It comprises all of the work on the North Platte River, extending from the town of North Platte on the east, near the 101st meridian, to the point where the North Platte enters the State of Wyoming from Colorado, at about the 107th meridian, a distance—measured by the winding river—of about 500 miles. The project lies about 100 miles northeast of Cheyenne, Wyoming. In the easterly portion the rainfall is at times sufficient to grow crops, while in the western portion arid conditions are found. According to the last census, within the drainage basin of the Platte River is found the largest area of land irrigable by one stream in the United States and the value of the improved agricultural land is probably as high as that of any other section, with the possible exception of the fruit belt of California.

The building of the Interstate Unit of this project is already completed, as is also the Pathfinder Dam and storage works. The building of the Fort Laramie Unit, on the south side of the river, was authorized during the summer of 1915, and active operations are now under way on the construction of the main canal and the surveys of its distributing system. No land will be available for homestead entry under this unit until water is available therefor.

The North Platte River carries the run-off from a large and mountainous territory. Its catchment basin contains the mountains of North Park in Colorado and the Ferris, Green, Seminole, Laramie and inferior ranges in mountainous Wyoming. Through its tributary, the Sweetwater River, it also carries the run-off from a considerable portion of the Continental Divide. Rising in the mountains of northern Colorado, the river flows in a northerly direction into Wyoming, where after traversing half the State, it turns to the southeast and continues in a southeasterly direction to its junction with the South Platte in central Nebraska. These geographical features determine largely the principal characteristics of the stream. During the spring and early summer the melting snows of the mountains swell its volume to large proportions, while in the late summer the long continued droughts shrink its volume to that of a small stream distributed over a wide stretch of shifting sands.

On account of this irregularity of flow of the North Platte River it was found necessary to provide means for the storage of the flood waters of the spring and early summer, in order that they might be delivered to the thirsty lands under the various canals evenly throughout the season. To meet this necessity the Pathfinder Reservoir was built. This reservoir receives the drainage from about 12,000 square miles, and the river has an average run-off of 1,400,000 acre-feet, at Pathfinder Dam. The area of the reservoir at the level of the spillway is 22,600 acres and the capacity is 1,100,000 acre-feet.

The dam is one of the largest masonry dams in the world, rising 218 feet above the rock foundation. It is 432 feet long and 10 feet wide on the top and is 80 feet long and 90 feet wide on the bottom. It is located about 3 miles below the junction of the North Platte and Sweetwater rivers, where the canyon is about 90 feet wide at the bottom and 200 feet wide at the top, the sides for the upper 75 feet being nearly vertical. The depth from the top of the canyon to bedrock in the foundation is about 200 feet.

To divert the flow of the river during the construction of the dam, and to serve as an outlet for the reservoir, after its completion, a tunnel was driven through the northerly abutment of the dam, and was provided with gates of large capacity to regulate the outflow. On the north side of the river a spillway 600 feet long was cut in solid rock adjacent to the dam to allow the discharge of surplus water after the reservoir is filled. Near the south end of the dam an earthen dike was built to close a gap in the wall of the reservoir, which was lower than the spillway. This is needed because of the fact that a few hundred feet south of the Pathfinder Dam occurs a low saddle in the margin of the reservoir about 30 feet below the level of the spillway. Naturally this must be filled to retain water to the full height of the rest of the dam. An earthen dike, 1600 feet long and 40 feet in maximum height, with a core wall of reinforced concrete, was built, with the water slope paved with rock to resist wave action.

The water stored in the Pathfinder reservoir is diverted by a concrete dam, near Whalen, Wyoming, about 150 miles from the Pathfinder. The canal into which it flows is known as the Interstate Canal, as it supplies land both in Wyoming and Nebraska. Provision is also made at this dam for the later construction of a canal on the south side to be called the Fort Laramie Canal. The Whalen Dam is a concrete, overflow, ogee weir, founded on rock. Provision is made for taking water from both ends of the dam, and two sluice-gates are provided at each end for clearing the entrance to the canals. The headgates of the Interstate Canal are placed at right angles to the dam, and are of cast iron, 9 in number, working in a structure of concrete.

In order to provide additional water-storage near at hand to the lands to be irrigated, and at the same time lessen the risk of water shortage were a break to occur in the main canal—a liability which increases with its length—two reservoirs, Lakes Alice and Minitare, have been formed, the former nearly 100 miles from the head of the canal, and the latter 12 miles still further east. Lake Alice has a capacity of 11,400 acre-feet, and Lake Minitare of 67,000 acre-feet, and these two reservoirs are used to supply a large area that, were they to depend upon the main canal, would be liable to shortage during the period of greatest irrigation need.

Lake Alice Dam is an earthen structure about 30 feet in maximum height, and 3,100 feet long. It has a top width of 20 feet, the water slope is 3 to 1, and the down-stream slope 2½ to 1.

The outlet consists of a reinforced concrete culvert containing three conduits 4 feet high, and 3 feet wide. There are three gates of cast iron controlled by hand power, and a groove for flashboards to permit shutting off the water in case repairs to the gates become necessary.

The Minitare Dam is an earthen embankment with a down-stream toe of gravel. Its maximum height is about 65 feet above the valley, and its length is about 3,700 feet. A short distance above the centre line it has a cut-off trench and a core-wall of reinforced concrete reaching deep below the surface, varying from 6 to 34 feet. Its top width is 20 feet. The water slope is paved with concrete blocks 8 inches thick, 10 feet wide, and 20 feet long, underlaid with 12 inches of unscreened gravel.

The North Platte Project has an average altitude of 4,100 feet above sea-level, and its soil varies from sand to sandy loam. It is rather rolling, being in places quite rough and difficult to irrigate. This is indicated by the fact that 6,445 canal structures are provided for the irrigation of 129,684 acres of land on 806 miles of canals.

Seepage from the canals and excessive irrigation by ignorant or careless farmers have caused the rise of ground-water in some localities, but this has been counteracted as far as possible by drainage, 13 miles of open and 9 miles of closed drains having been constructed. In 1915 there were 1,050 farms receiving water, covering 73,881 acres, though the project was prepared to supply over 129,000 acres, 83,000 acres of which are in public, 29,000 acres in private ownership and 17,000 acres under the Carey Act project of the North Platte Canal and Colonization Company, in Wyoming. These lands are mesa or table lands lying from 50 to 200 feet above the river. Between this table land and the river there is bottom land about one mile in width which has been irrigated for a number of years, the principal crops being alfalfa and native hay, sugar beets and small grains.

The lands under this project are practically all prairie sod and therefore need no clearing. For the most part the surface is so even that it may be successfully irrigated without levelling or preparation other than such tilling of the soil as is necessary to plant crops. There are numerous pieces of ground, however, on which irrigation can be greatly facilitated by proper preparation or where the levelling of the ground is a necessity. Farmers who are unacquainted with the necessities of irrigation and the methods pertaining thereto, will do well to inspect carefully the land they propose to buy and ask the advice and opinion of the successful irrigators in regard to the work of preparation required for such lands as they propose to purchase. Of course experienced irrigators who understand the necessary preparation of the ground do not need this advice. As a fair estimate it may be stated that in but rare cases the cost of preparing land for irrigation would amount to more than $15 per acre, and at least 80 per cent. of the land of this project needs no irrigation preparation whatever, other than the ploughing of the necessary distributing laterals.

One of the most attractive features of this much-favoured valley is its sunny, invigourating and health-giving climate. The summers are always comfortable and the winters relatively mild, with little rain or snow. Extremes of heat and cold are seldom known. The heat during the day in summer is tempered by breezes and the extreme dryness of the atmosphere, and the nights are always cool and comfortable. The maximum temperature in summer reaches 104° and the lowest recorded temperature in winter is 30° below zero. It is seldom that the thermometer reaches zero every night for ten consecutive nights, the cold periods generally lasting about three days. The annual precipitation varies from 10 to 24 inches, with a general average of 15 inches.

Contrary to expectations of the newcomer, there is little snow in winter. So rare, in fact, is snowfall, and it disappears so rapidly, that a sleigh or sled is rarely seen. On the other hand, we find that the greatest rainfall is in the months of April, May, June and July, the period when moisture is most needed for the growing crops; while for September, October and November, the months of harvest, the rainfall is the minimum, thus insuring the saving of crops without damage from rain. The number of days in the year in which rain falls averages about 50; clear days, 250; partly cloudy, 95; and cloudy, 20. Storms occur at intervals between November 1st and April 1st. Experience has shown, however, that severe storms do not occur every winter. By reference to the climate and crop-service reports of the weather bureau, we find that the last frost usually occurs the early part of May and the first about the middle of September. This record refers to a minimum temperature of 32° and does not always mean that these were killing frosts. The native in the valley believes that no damage will come to his most tender crops after May 12th, nor before September 20th. Taken as a whole, the climate is superior; the large number of days when the sun shines, the dry atmosphere and the certainty of beautiful weather, render the valley a desirable residence portion of the United States. While the temperatures appear to be low in winter, the extreme dryness of the atmosphere makes it less severe on man and beast than an equal temperature in the humid region.

The soil is a sandy loam of excellent quality, free from alkali and other injurious substances. It is easily worked and particularly well adapted to the raising of first-class potatoes and sugar beets. The native vegetation consists of buffalo grass, grama grass, what is locally known as wheat grass, otherwise bluestem, and blackroot.

All of these afford excellent range where not over-

WHALEN DIVERSION DAM AND HEADWORKS
NORTH PLATTE PROJECT, NEBRASKA-WYOMING

SPRING CANYON FLUME
NORTH PLATTE PROJECT, NEBRASKA-WYOMING

grazed. Wheat grass in particular, which soon appears wherever the ground is irrigated, makes good hay and brings on the market at Omaha, Kansas City and Denver, a higher price than timothy. The cactus, or prickly pear, is much in evidence, indicating the richness of the soil. The plant is entirely destroyed by the first ploughing and wherever it grows the land is considered desirable. The cultivation is easy, as there is no heavy adobe soil to contend with. The soil is readily subdued, and like the soils of the entire plains region, it is fertile, containing a large amount of mineral plant food. On the benches, which are quite smooth and gently slope to the south and east, the sandy loam extends to a considerable depth, except at the points where the hills project out into the valley.

The prevailing winds are from the west. In this respect, as also in temperature, the climate is similar to that of Colorado. There is a period of blustery and disagreeable spring weather in evidence during the months of March and April, extending sometimes into May, during which period most of the wind movement occurs. From June 1st to the end of the year, the winds are moderate and pleasant, tempering the heat of the warmest days in summer.

The principal crops of the project are alfalfa, grains, potatoes and sugar beets. While fruit is not grown to any great extent for shipment, many farmers produce an abundant supply for their own use and the local market.

Much of the alfalfa grown is fed to cattle and sheep from the stock range on both sides of the valley, and from Wyoming and Montana. Some farmers buy stock in the fall, fatten them during the winter and market them in the spring, while others sell their alfalfa in the stack to stock men to be fed on the premises. Several thousand tons are also shipped, baled, every year to Missouri River points. Alfalfa meal mills at Mitchell and Gering also take 500 tons or over a month.

Truck farming, ere long, doubtless will become one of the most profitable of occupations in the North Platte Valley. Beans, peas, tomatoes, squash and pumpkins thrive abundantly, and they are of the fine flavour and quality that satisfy the most exacting demands of the canners. There are several small canneries indicated in the no distant future. There are also a few farmers who are already making a specialty of growing cabbage, watermelons, canteloupes and onions.

Bees also thrive well and make an abundance of pure, white, deliciously flavoured honey, combining the product from the wild plants and the alfalfa and clover.

Cattle raising on the open range is now almost a thing of the past here, but the country is rapidly becoming one of the great dairying regions of the West. There is a growing demand for every pound of butter-fat that can be produced, and at a good price.

While the open range has gone, many farmers are making a profitable business of breeding fine cattle and sheep for market, and thoroughbred dairy stock. There is also a great demand for horses and mules, which some farmers are supplying to a greater or lesser extent.

Hogs do well, in the neighbourhood of 300 carloads having been shipped the past year.

While flies and mosquitoes are frequent in certain seasons of the year, other pests are unknown, and as people understand better the scientific control of flies and mosquitoes they will speedily disappear.

The principal markets for all the products which may be raised in the North Platte Valley are Denver, Wyoming, Nebraska and Missouri River points. Dairy products, eggs, poultry and garden truck all bring high prices and there is a constant and growing demand for these farm products. The great markets of the Middle West—Omaha, Kansas City, Chicago and other large cities—take all surplus products, sending in return machinery, household supplies and other manufactured articles not yet produced in the valley.

Thus, in a few years, the marvellous change has taken place. There is no longer any expansive, deserted, uncultivated valley of the Platte.

The great and expansive plain from which the old deserted highway is fast disappearing, leaving only thrilling memories of "The Pathfinder," the "Forty-niner," the dashing soldier of fortune and the patient pioneer, is rapidly becoming the home of the prosperous small farmer and is undergoing a transformation never dreamed of twenty years ago. The days of the cattle baron in this valley are past and he is being driven farther and farther into the hills each year by the rapid approach of the incoming settlers. The great range is being divided into small farms of 40, 80 and 160 acres. Where, but a short time ago, the coyote and prairie dog were the only inhabitants, irrigation has built up large communities; large fields of alfalfa, sugar beets and other crops are taking the place of the native grass. Although still in its infancy, this valley is keeping step with the development of community life in other parts of the country, taking great pride in its schools, churches, and other social and intellectual organizations.

The principal towns embraced in the North Platte Project are on the north side: Guernsey, Lingle and Torrington in Wyoming, and Henry, Morrill, Mitchell, Scotts Bluff, Minitare, Bayard and Bridgeport, in Nebraska. Guernsey is located 8 miles above the headworks of the Interstate and Fort Laramie Canal, and although not in the irrigated section is a thriving town of about 400 people. Torrington is the county seat of Goshen County and has a population of about 700. Henry, a town of about 100 people, on the State line, attracts many visitors in the summer on account of the good fishing nearby. Morrill is a thriving town of about 500 people, and is the railroad point for Dutch Flats. Mitchell is a prosperous town with 1,000 inhabitants, containing the headquarters of the Reclamation Service for the North Platte Project. Scotts Bluff is the largest town in the North Platte Valley, with a population of 3,500. The second largest sugar factory in the West is located here. Minitare and Bayard are thriving towns lying within the irrigated district with populations respectively of about 500 and 400. Bridgeport, the junction of the Bridgeport-Guernsey line with the Denver-Alliance branch of the Burlington Railroad, is the county seat of Morrill County. It has a population of about 700. The towns named are from 8 to 15 miles apart; the distance between Bridgeport and Guernsey is 98 miles.

On the south side of the river, the Union Pacific is building a line from North Platte, Nebraska, westward through the valley, its terminus on January 1, 1916, being about 10 miles west of Gering. This is the oldest town in the valley, having now a population of about 1,000 inhabitants, and is the county seat of Scotts Bluff County. With the advance of the North Platte branch of the Union Pacific Railroad, the new towns of Haig, Melbeta and McGrew are starting on the south side of the river, none of which has a population exceeding 100 inhabitants.

With the development of the public and private irrigation systems in the valley, these towns have grown steadily, substantial buildings have been erected and light, water and sewer systems have been built in nearly all the larger towns.

An abundant supply of well water of excellent quality may be obtained at nearly all points on the North Platte Project at depths of from 20 to 200 feet and usually within 100 feet. On account of the depth there is little danger of contamination. Most wells will supply sufficient water for all the stock the farm will support.

Reference has been made to a contemplated canal —the Fort Laramie—which is to flow from the Whalen Dam on the south side of the river. Construction already has begun on this. It will have about 25 miles of heavy construction, including three tunnels aggregating 8,550 feet in length. It will cross the Goshen Park and irrigate about 55,000 acres in Wyoming, mostly State and public land, and about 45,000 acres in Nebraska, mostly private land. Later it can be extended to cover more land in Nebraska should the water supply prove sufficient. This canal system is already known as the Fort Laramie Unit and will be ready to supply water in 1918.

The size of farm units on this project for public lands is 80 acres, and the construction charge is $55 per acre, payable in 20 years without interest.

The Pathfinder Unit is already completed, and the Interstate Unit almost so, while work on the Fort Laramie Unit is now fairly well under way.

The present Project Manager is Andrew Weiss, with offices at Mitchell, Nebraska.

CHAPTER XIX

THE TRUCKEE–CARSON PROJECT

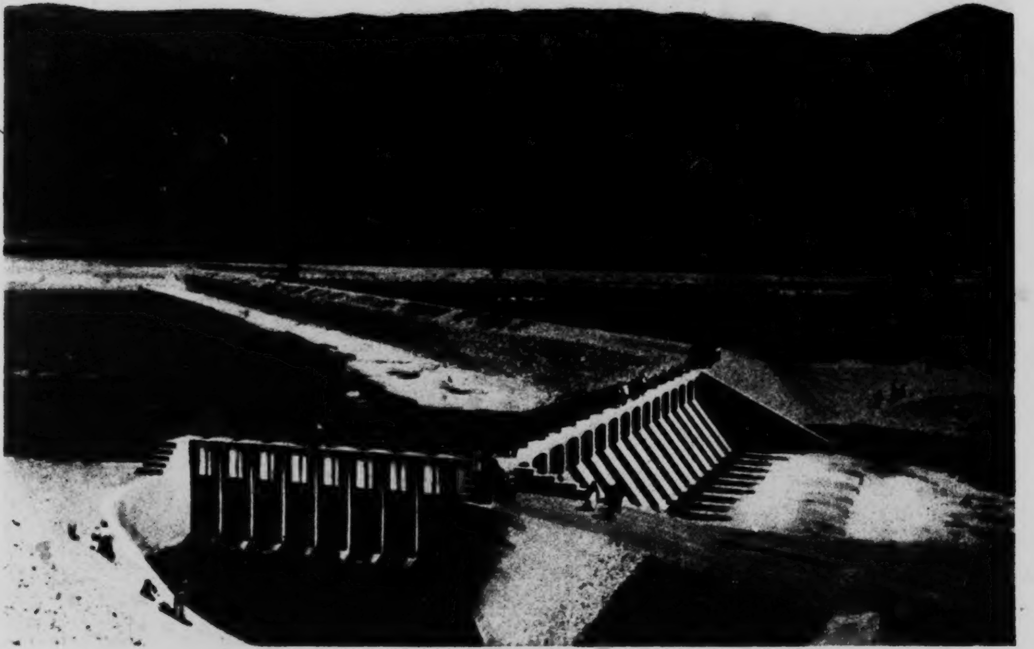
One of the beauty spots of the world is Lake Tahoe—the Lake of the Sky, located on the eastern edge of the High Sierras, partially in California and partially in Nevada, surrounded by snow-crowned peaks that companion the stars and set forth the pure blue of one of the bluest skies ever seen by man. This jewel of a lake—though the word jewel may suggest that it is small, in reality it is with but one exception the largest lake *at its altitude*—6,225 feet—in the world—is so pure blue, and its waters so clear that Mark Twain said of it: "So singularly clear was the water, that where it was only twenty or thirty feet deep the bottom was so perfectly distinct that the boat seemed floating in the air! Yes, where it was even *eighty* feet deep. Every little pebble was distinct, every speckled trout, every hand's-breadth of sand. . . . Down through the transparency of these great depths, the water was not *merely* transparent, but dazzlingly, brilliantly so."

This lake has fully a hundred sources in the springs that bubble up on the mountain sides, and streams that come dashing down, yet, strange to say, it has but one outlet—the Truckee River. Following a winding and meandering course on the California side of the Lake, it soon flows north, then twists around to the east, cutting its way through the ancient lava flows of the Sierras, and then aims for one of the "sinks" of the Nevada sage-brush plains, where it forms another lake, named by Frémont, Pyramid Lake, from the peculiar pyramid-like rock that stands within its waters.

Another river, originating in the snow-fields of the eastern slopes of the Sierras, is the Carson, named by Frémont after his able scout and lieutenant, the Indian-fighter, Kit Carson.

For centuries these two rivers have flowed on in their respective channels, of little use to man, except the few Paiuti and Washoe Indians that occasionally camped by and fished in them. During later historic times the Carson has had two outlets, one emptying into Carson Lake, the other into a great flat dried-out lake bed, or *playa,* commonly spoken of as the Carson Sink. This latter-named end of the Carson River has always appeared pathetically useless to me. Beginning in the snowy fountains in the sweetest purity, and evidently with the finest promise, the river flowed its course and then emptied its water out upon the desert area, known as the Carson Sink, where it was evaporated by the sun. The Truckee River made a beautiful lake, but the Carson succeeded in making only a mud puddle, where a few lost ducks now and again wandered, and where some unfortunate traveller cursed his luck at having to pass over such a barren, desolate, and—to him it seemed—God-forsaken spot.

The geologists, however, tell us that this Carson Sink was once a part of a great interior lake, which extended almost entirely across Nevada, and which they named Lake Lahontan, after the French ex-



Diversion Dam on Truckee River, Southern Pacific Train in background
Truckee-Carson Project, Nevada

plorer. When the gold hunters crossed the plains in 1849 and came by the central route, one of their dreads was this Carson Sink. In the summer months it became so baked and hardened as scarcely to receive an impression from a horse's hoof, and so sun-cracked as to resemble tessellated pavements of cream-coloured marble. But when the rains fell and the snow of the mountains began to melt rapidly, the water would spread out over it sometimes forming a lake in a single night, only to evaporate in the sun of the next succeeding two or three days. When the weather was unsettled one traveller would pass over the *playa*—as this evaporated lake bed was called—and he would complain of its dryness and the intense heat which beat up into his face with distressing force from the bare surface, while another traveller, coming, perhaps, a week later, would curse the intelligence of men who knew so little as to make a road through the bed of a muddy lake.

But here, as elsewhere, man did not judge the larger plan of the forces that control our mundane sphere. The river was constantly bringing down valuable soil deposits from the mountain slopes, and here was being prepared a valley which, when its appointed time arrived, could become one of the fertile garden spots of the world. The passing of the Irrigation Act was that appointed time. As Senator Newlands, of Nevada, was the statesman to whom the American commonwealth is indebted for the formulation of the plans that ultimated in the organization of the United States Reclamation Service, it was nothing but fair (although it was also a pleasing piece of poetic justice) that his state should be one of the earliest beneficiaries of its helpful operations.

Here, then, were the conditions: on the one hand, a large area of desert waste, but rich land, utterly useless to the world, and, at times, a curse to the weary traveller; and, on the other, two rivers extravagantly and wastefully pouring out their water, which might have been life-giving, to be lost in the heart of the desert. To bring them together, and then scientifically apply the water to the land, was the test set before the engineers of the Reclamation Service. Hence the name given to the work, combining the names of both the rivers, the Truckee-Carson Project.

While the major part of the Carson Sink is of the character described, some portions of it are sandy, and the outskirts of the playa are covered with greasewood and sagebrush and other desert vegetation.

To irrigate this, and other feasible lands, a steady supply of water must be assured, and, as there were many private locators on and near the Truckee River in the vicinity of Reno, and also on the Carson River, their interests must be conserved as well as those of the later settlers who might come and locate upon the Government's vacant and arid lands. Lake Tahoe was thereupon decided to be an ideal storage reservoir. With its area of 193 square miles, a slight rise or fall would mean thousands of acre-feet of water more, or less, for the users in the far-away valleys. Yet it must be remembered that Lake Tahoe is one of the noted scenic resorts of America. Thousands of visitors flock to it annually from California and Nevada and the rest of the world, and there are in the neighbourhood of twenty to thirty hotels, taverns, resorts, and camps permanently located on its shores, together with scores of summer-homes, representing the investment of many millions of dollars. To play fast and loose, therefore, with the water-supply of Lake Tahoe would be impossible. Too great a rise in the water-content of the lake would jeopardize the interests of those residing there, and too great a fall would destroy—in some measure—its scenic beauty and therefore its desirable quality to the summer resident, camper, and tourist.

Recognizing these facts the Reclamation Service made a thorough study of the situation, discovered the reasonable fluctuations between normal high, and normal low, water, and then agreed to observe a mean—provided Nature concurred—above which no water should be stored, and below which the water should not be allowed to fall.

Another important fact could not be overlooked. That was that certain power-plants relied upon the steady and continuous flow of the Truckee River to operate, and as Fall and Winter constitute the low-water season, the draft on the storage in Lake Tahoe is greatest at that time, and not being then needed for the irrigation of the desert lands, would be entirely lost for such a purpose, unless it could be stored elsewhere.

The area that it was designed to irrigate—some 200,000 acres—was mainly in the basin of the Carson River, yet the surplus of water was found to be in the Truckee River. There was no natural reservoir provided for the storage of the water of the Carson River, so one must be built, and some means must also be devised of conveying the surplus water of the Truckee so that it could be united with that of the Carson and thus stored until it was needed. To do this the Lahontan Reservoir was erected on the Carson River, where the drainage area is in the proximity of 1,000 square miles. This has a capacity of 290,000 acre-feet and covers an area of 12,000 acres. The storable run-off often falls below 100,000 acre-feet in a year, and at such times this reservoir and the lands it irrigates must depend upon the Truckee River and its headwaters in Lake Tahoe.

Lahontan Dam is one of the most unique and interesting structures built by the Reclamation Service. It is an earthen dam, and yet was built in a river channel with a recorded flood of 20,000 cubic feet per second, and a possible flood of twice that amount. The site is at a point where the Carson cuts through a gorge about eight miles south of Hazen, Nevada, on the main-line of the Ogden route of the Southern Pacific Railway. The right bank rises abruptly about 125 feet, as a bluff of broken and seamy rock, inclined in all directions, and badly faulted. The left bank rises rather abruptly for fifty feet, where a gently sloping bench occurs, 350 feet wide, above which another steep rise of 75 feet occurs. Both sides slope gently from the bluffs to the foothills, which are about a mile from the river on the north, and two miles on the south. Borings made by the engineers showed the foundation to be similar to the abutments and also revealed movement of underground waters and some artesian flow.

To provide a solid dam of earth under the above described conditions, capable of withstanding the pressure of the continued storage, and of the fierce floods of springtime, that would also prevent unreasonable seepage, required many days of serious thought, of testing and experimentation. But in due time the work was done. The dam has a top width of twenty feet, a water slope of three to one protected by twelve inches of gravel and two feet of hand-placed rock. The down-stream slope is two to one, and is covered by fifteen inches of dumped rock from a nearby quarry. Its maximum height is 124 feet, maximum base thickness 660 feet, and it has a crest length of 900 feet, or 1,400 feet, including the spillways. These are 250 feet long—one at each end of the dam. They converge by means of guide walls, and descend on concrete steps to a central pool in the river-bed below the dam.

As an illustration of inventive genius applied to problems as they arise these spillways are interesting. Had they discharged into the bed of the river, washing and cutting back would have been inevitable, to the great detriment of the dam. But by making twin spillways, one on each side of the dam, the overflows are perfectly adjusted as to bulk and force, and the streams impinge on each other above the pool, thus destroying each the energy of the other and whirling about harmlessly in the pool from which the water flows gently down the river.

The highest flood in a record of twelve years is about 20,000 cubic feet per second. This quantity of water would flow over the weir at a depth of five and a half feet. The top of the embankment is twelve feet above the crest of the weir, and the area of the reservoir of 12,000 acres would have a large regulating effect on any flood, so that the engineers believe that one might occur of three times the above recorded power without damage to the main portion of the dam.

To convey water from the Truckee River to this dam, it was essential to construct a diversion dam in the Truckee River, and then build thirty-one miles of canal. As the water from this canal was required to irrigate certain bench lands, near Fernley, on the Truckee River, and also for the delivery of 200 second-feet of water to a fertile area in the vicinity of Pyramid Lake, and further, it was needed to generate power at Lahontan for the construction of the great dam, this portion of the work was done first. Construction was begun in 1903. The dam was located about ten miles above Wadsworth, on the Ogden route of the Southern Pacific Railway. At this point the river crowds the mountainside on its right bank, and leaves a small, gradually sloping valley on the left. The diversion is made by a long, earthen dike across the valley, and a concrete structure in the river-bed, consisting of a series of sixteen gates of 5-foot horizontal opening, with 5-foot piers between, making the distance between abutments 155 feet. This is the structure that may be seen by east-bound passengers travelling on the Southern Pacific soon after crossing the California line into Nevada.

The headgates of the canal are eight in number, and placed at right angles to those of the river, the

Lahontan Dam, Spillways and Power-house, Carson River
Truckee-Carson Project, Nevada

two sets of gates and their foundations forming one structure and using one abutment in common.

After this dam was placed in operation, a great flood occurred in 1907, far beyond previous records, which carried a large amount of drift-wood. As a result of this experience, it was deemed advisable to remove the top of one pier in order to provide automatic passage for drift.

To prevent the entry of water beneath the gates a curtain-wall of concrete was carried three feet below the foundation on the river-side of the headgate structure.

For over ten miles the canal is in a canyon, with steep side-hill construction, largely in rock, so that for economy in building it was made narrow and deep, the water depth for full canal being twelve feet. There are three tunnels, respectively 901, 309, and 1,515 feet long. These are twelve feet wide and have a water-depth of thirteen feet. Canal and tunnels are both lined with concrete.

At a point in the canyon, about four and a half miles below the heading, a waste-way is provided by means of which the canal may be emptied quickly in case of a threatened break or any emergency requiring such action.

On its arrival at Lahontan the carrying capacity of the canal has been reduced to about 800 cubic-feet per second, and discharges at about 125 feet above the river-bed. Advantage was taken of this fact to locate a power-plant by dropping a portion of the water through turbines below the dam-site. These turbines are 24-inches of 830 horse-power each, operating under 110-foot head, and the current is generated at a pressure of 2,300 volts. It was used for operating the drag-scrapers, loading sand and gravel, etc., during the construction of the dam, and is now increased in size and power and the electricity leased to the cities of Fallon, Hazen, Rochester, Lovelocks, and Battle Mountain. Fallon, sixteen miles away, is thus supplied with ample electric current for all purposes. This is available for manufacturing, and already the city is well lighted and watered through the use of this electric power. The city water-supply pumps are motor-driven from this source.

The electric current is also used to operate the mills at the famous Rochester mines, as well as for pumps for irrigation, and power-plants for industries within reach of its transmission line, which is more than one hundred and fifty miles in length.

To divert the water of the Carson River a dam was built about five miles below the Lahontan Dam closely resembling that on the Truckee. It is 225 feet long between abutments, and has 23 openings of five feet each, closed by cast-iron gates of designs similar to those on the Truckee.

Two canals head here, the larger being on the right bank, and having a capacity of 1,500 second-feet. Nearly six miles below the headgates the main canal has a drop of twenty-six feet in its water surface, in passing from the bench to the bottom-lands. The excess fall was concentrated at this point so that eventually it may be utilized for power purposes, and the structure provided was designed with such use in view.

Up to January 1, 1915, the costs of construction on this project were nearly six millions of dollars. This included 104 miles of main canals, 420 miles of laterals, 178 miles of surface drains, 4 miles of tile drains, and many concrete and wooden structures, as well as the hydro-electric plant before referred to. It should also have been stated that concrete headworks were erected at Lake Tahoe to regulate the outflow of water into the Truckee River.

In 1913 about 43,000 acres on the project were under irrigation. About half of these were homesteads, the others being in private ownership. Additional public- and privately-owned lands will be opened as settlement demands, until the whole 206,000 acres will be under irrigation and cultivation. As there are several very different kinds of location on the project, the soils have a great range in variety. A fine sandy soil resembling volcanic ash is the characteristic of the Fernley district. In the "Island" and "Stillwater" districts where the land is very smooth and level the soil is of a sandy loam, merging into heavy clay formation with certain areas of a peaty nature, while in the "Fallon" and surrounding districts the soil varies all the way from light sand to heavy adobe ground. Practically all of these soils yield abundantly when properly prepared and there does not appear to be much choice so far as productiveness is concerned, although there is quite a difference in the mode of preparing, cultivating and irrigating for the best results.

There is an experimental farm maintained by the Department of Agriculture, where much instructive information is to be obtained regarding the character of crops and methods of cultivation which are best adapted to this locality. Settlers may also obtain here limited numbers of trees and shrubs which are adapted to the locality.

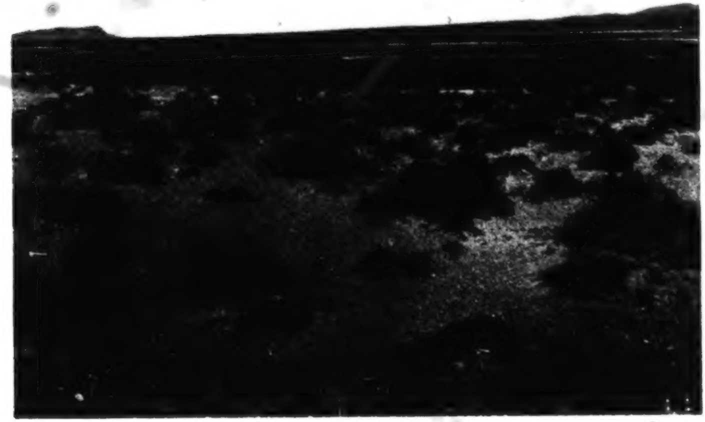
The work required for levelling and preparing for irrigation varies greatly in the different sections; the cost in some instances being only that of removing the brush and furrowing, while in the sand-dune country the expense of grading to a satisfactory surface may run as high as $50, or even more, per acre. There are many expert land levellers on the project who contract for outside work in addition to their own.

There are fine *bench* lands already under cultivation at the present time at Hazen and Fernley. The latter is one of the new towns that has sprung up since the project began, and is on the main line of the Southern Pacific, about 35 miles east of Reno. These benches slope towards the north to the foothills of the Sierra Nevada range. While these lands are part of the Truckee-Carson project, geographically they form a unit in themselves.

The soil is of a different character from that in the neighbourhood of Fallon, being of a gravelly sandy-loam, in some parts rather rocky, and, evidently, at one time, near the shore-line of the ancient Lake Lahontan.

Its gradual slope to the north, with a fall approximating 100 feet to the mile, necessitates a furrow system of irrigation, but with this fall, any surplus of alkali is quickly washed out. Seepage from the canal along these uplands is practically unknown,

The City of Fallon on what was once the Carson Desert
Truckee-Carson Project, Nevada



A Part of the Nevada Desert before Reclamation
Truckee-Carson Project, Nevada

and the question of high water-table is entirely absent over most of this section.

Up to the end of 1914, the district has been entirely devoted to alfalfa, but in 1915 the older and more settled ranches began to grow with great success and profit, potatoes, sugar-beets, onions, etc. Five tons to the acre per season of alfalfa is no unusual yield and three first-class cuttings are harvested. Some wonderful truck gardens have been developed, and small fruits do well. The success of fruit trees is rather uncertain, and no orchards have been planted on a large scale. This location is ideal for dairy farms and the feeding of cattle.

There are additional bench lands to be developed in the future between Lahontan and Hazen, across the Carson River and south-east of the Lahontan Dam, and an excellent tract in the vicinity of Pyramid Lake. The general description given of the Fernley bench lands equally applies to these other sections, hence as soon as they are opened to the public they will doubtless be eagerly taken up.

The general elevation of the project lands is 4,000 feet above sea level. Temperature ranges from 0° to 100° Fahr. Precipitation averages four inches annually. Snow rarely falls and usually does not lie on the ground more than a day or two. The air is extremely dry. Humidity is seldom felt and the climate generally is temperate and delightful. Due to the altitude, late and early frosts are to be expected, but these ordinarily do not interfere with the great variety of crops which are successfully grown. The single drawback to the climate is the occasional wind and dust storm, the worst of which are disagreeable but never destructive.

The ruling farm unit is the 80-acre subdivision containing usually not less than 40 irrigable acres. It is possible for lands in private ownership to acquire water rights up to 160 acres, but with further extensions of the project and improved methods of cultivation the tendency will be toward the adoption of the 40-acre farm unit which is found to be ample when intensively cultivated for the support of a family.

Owing to the great variety of soils an equal variety of products can be successfully and profitably grown upon them. While alfalfa is still the stable crop, it is being supplemented by many others.

It yields on good soil from five to seven tons of hay per acre. Wheat yields 35 bushels, barley 50 bushels, and oats 75 bushels per acre. Corn has not been grown except in an experimental way, but promises to become an important crop; it will yield from 30 to 60 bushels per acre. Kaffir corn, milo maize, millet and many other forage crops of this kind have been tried, and promise to become useful to the farmers. Every kind of garden vegetable has proven successful. Melons of excellent quality have been raised, and bring high prices in the mining camps close by, while all kinds of green stuff which can stand one or two days' shipment to the mines, have been a most important source of revenue.

It is claimed that apples, pears, peaches, plums, apricots and cherries all do well, but one should be sure of his ground, and the climatic conditions, before planting these fruits too extensively.

The Carson Sink Valley is perhaps one of the best potato-growing regions in the West. It is producing potatoes of the best quality, and where they have been handled intelligently the yields have been as great as they generally are in the Greeley country of Colorado, or in California. The mining-camps of Nevada pay high prices for potatoes, and outside districts cannot compete in shipping to these mines. Furthermore, the Nevada potatoes on the San Francisco market sell at a premium, for California people appreciate good potatoes, and realize that Nevada can produce them better than can their own farms.

Sugar beets have been experimented with and have proven first-class in every particular. They carry the highest per cent. of sugar and purity of any locality in the United States, and the yield is enormous. As a result of careful experiments a factory of 500 tons' capacity, and costing $600,000 has been erected and is now in active operation. Onions also are grown on a large scale. The yield is far more than the average, the demand greater than the supply, and the prices large.

While cattle and sheep in large numbers are raised here, and many more are brought in from the open ranges to be fattened, hog-raising seems to promise large returns. Fine hogs do remarkably well, and seem free from the diseases that hamper breeders elsewhere. George Wingfield, the Nevada millionaire, has established a large creamery at Fallon, and has adopted a fine plan for securing the best of cream for his butter. He purchased several carloads of thoroughbred dairy cows which he sold to the farmers, agreeing to take his pay either at so much per month, or by holding back one-half of the monthly pay-check for the cream sent in by the rancher. The result is one can ride over the farms of this project and see some of the best dairy stock in the West. The poultry industry here is very profitable, the mild dry climate being especially favourable for raising turkeys, which command premium prices on San Francisco markets.

Although the engineering work is not yet entirely completed, some three millions more having been set aside for this purpose, the development that has so far occurred is remarkable and wonderful.

Fifteen years ago there was no such town as Fallon. Now it is the principal city not only on the project but in the county,—indeed it is the County Seat, has a population of between 1,500 and 2,000, and it is a thoroughly progressive and up-to-date western city. It owns its electric-lighting and power-, water,- and sewer-system, and is the headquarters for the only county in the United States—so I am informed—that owns and operates its telephone system. Many of its homes and business houses are built of stone and concrete, and it is a thriving, self-respecting, and progressive community.

The schools,—graded and high school,—are well supported, and the district schools are sufficient for local needs. Union district schools are now being promoted. It also has two good weekly newspapers. All the principal churches and fraternal orders are represented. A theatre, skating-rink, dancing-pavilion, and such social accessories are also well patronized.

Fernley is also growing into importance. It is the turning-off point for the Fernley Branch of the Southern Pacific.

The present Project-Manager is Mr. John T. Whistler, with office at Fallon, Nevada.

CHAPTER XX

IN THE LAND OF THE DELIGHT-MAKERS.
THE CARLSBAD PROJECT, NEW MEXICO

The Pueblo Indians of New Mexico have been irrigationists for thousands of years. On the upper Rio Grande, and at Laguna, Acoma, Zuni and their dependant villages they have been accustomed from time immemorial to construct their rude and simple diversion dams, convey the water to their fields and irrigate corn, and other seed crops, and, after the advent of the Spaniards, peas, beans, chili, squash and a few fruits. Hence it is appropriate that this land should have appealed to the Mexican and White Settler and led them into the same method of soil and crop cultivation. As we have seen in other chapters the Mexican utilized what lands he could irrigate easily on the lower Rio Grande, and other streams, but neither he nor the Indian before him grasped the significance and importance of the storage of the destructive and wasteful spring floods. When the white man appeared this was what he sought to do, and the era of modern irrigation was at least fore-shadowed, if not actually ushered in.

One of the rivers of New Mexico that speedily appealed to the vision of the irrigation farmer—for without irrigation farming in New Mexico is practically impossible, as it is a genuinely arid or semiarid land—was the Pecos. It rises about 40 miles north-west of Las Vegas in the wooded and mountainous area included in the Pecos Forest Reserve, and flows in a general south-easterly course through the counties of Mora, San Miguel, Leonard Wood, Chaves and Eddy into Texas and thence to the Rio Grande. It drains a region above the Carlsbad Project of 22,000 square miles. Like all the streams of this region, it is almost dry at times, and at others is subject to violent floods. In 1915 one flood was estimated to flow at 80,000 cubic feet per second. These floods are heavily laden with sediment, and this is a serious problem to deal with, as naturally it has a tendency to fill any reservoir that may be provided. The annual run-off in acre-feet from 1899 to 1915 was maximum, 912,000; minimum 148,000; mean, 319,000. The average rainfall on the irrigable area, which has an elevation of 3,100 feet is 14.9 inches. In the year 1915 rain to the depth of 18.63 inches fell. The temperature ranges from -5° to 110° Fahr., and the length of the irrigating season is from March to November, and two weeks in winter, 260 days.

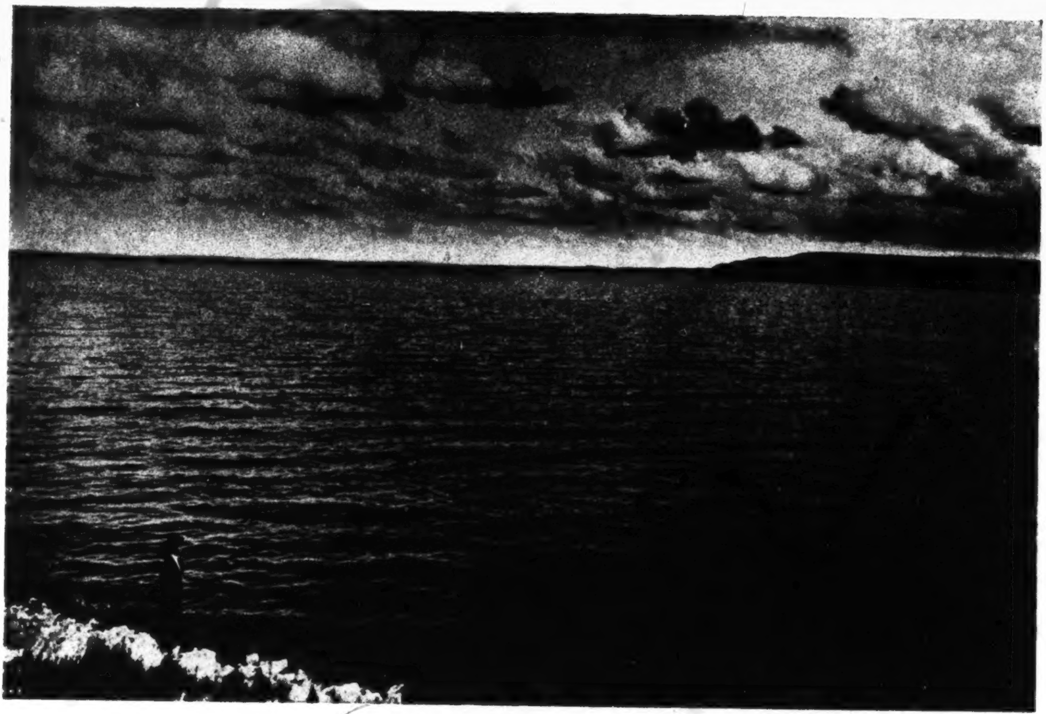
Where the Pecos River crosses Eddy County it flows through a valley from six to twenty miles wide, the soil of which is a sandy loam with considerable lime peculiar to this region, and which bears the name of the river. The success of the Indians and Mexicans in growing a variety of crops led to enthusiastic and eager settlement of this valley and the appropriation of all available water for irrigation. To overcome the difficulties and water shortages that arose, owing to the erratic flow of the river, the Pecos Irrigation Company was formed in 1890. It constructed two dams which created two large reservoirs, Lakes Avalon and McMillan, both on the Pecos River, with a system of canals which reached both sides of the Pecos. This system is said to have originally cost fully two millions of dollars.

For awhile all seemed to go fairly well, though considerable leakages or seepages—far above the average—were encountered in both canals and reservoirs, until October, 1904, when a serious flood occurred which carried away the Avalon Dam and greatly damaged the embankments of Lake McMillan and the distribution system. Owing to lack of finances the company was unable to rebuild the dam, and temporary expedients were resorted to for the conservation of such water as could be saved, but additional floods carried these away, and the 13,000 acres of land that were being irrigated were in danger of reverting to their original desert condition.

In this desperate strait the Pecos Company united with the settlers in a petition to the Reclamation Service to acquire the rights of the Irrigation Company and establish a permanent and secure system that should remove the dread that had begun seriously to disturb the serenity of the farmers.

In due time this was done, not because the Service deemed this one of the most desirable of projects to undertake, but purely to save a large and fairly thriving farming community from the certain ruin that threatened it. This fact should not be overlooked in estimating the value this great Service has been to the country at large.

After careful consideration by the engineers of the needs of the existing system to enlarge it and make it secure the Carlsbad Project may be said to include



Lake McMillan Storage Reservoir
Carlsbad Project, New Mexico

the following features: Storage in Lake McMillan, of the flood waters of the Pecos River, near Lakewood, N. M., and further storage, with distribution, in Avalon Reservoir, near Carlsbad, N. M., from which water is diverted into canal systems on both sides of the Pecos River.

As reconstructed the system is as follows: Avalon Dam was rebuilt with a reinforced concrete core-wall, with earth embankment on the water side and rock-fill on the down-stream side. This provision of a core-wall was an innovation upon the usual western practice, and especially that of the Reclamation Service. Its necessity arises from the presence of a large percentage of soluble salts in the earth available. In use, the slow percolation of water through such a bank gradually leaches out the soluble matter, leaving the bank more and more porous, and it soon becomes unreliable as a barrier against water. The core-wall thus serves as a strengthener and supporter, and also prevents destruction of the embankment by the ravages of burrowing animals.

The dam is combination earth and rock fill, 50 feet high and 1,380 feet in length. It serves primarily as a diversion dam, but has a storage capacity of about 5,000 acre-feet above the canal outlet, which is excavated in rock on the left bank of the river. The right side of the canal for a distance of 200 feet was closed by wooden gates to be opened in times of flood, and serve as a spillway. Two other spillways have been provided by the Service on the right or west side of the reservoir.

The large concrete flume, which carries the main canal across the Pecos River five miles below Avalon

Dam, was repaired and where necessary rebuilt. Its service now is perfect, as compared with that given prior to its reconstruction.

At Dark Canyon, where the original crossing had proven wasteful and inefficient, and had finally failed entirely, a substitute was adopted in a 6-foot reinforced concrete pressure pipe, 400 feet long, crossing the canyon under a head of about 20 feet.

Black River is a small stream that flows into the Pecos from the west, at the lower end of the project. Its waters are diverted by a canal on the right bank, to water about 1,000 acres of land. At times the Black River is inadequate for this purpose, and water is then furnished from the main canal through a branch reaching Black River above the diversion point. The old canal from Black River was so leaky that it delivered only a small percentage of the water turned into it. A new canal, lined with concrete, which is practically water-tight, was put in its place.

The Main Canal has been almost entirely rebuilt. In some places, where it passed through formations of gypsum that were so porous as to leak constantly, a new and lower line was found, and the whole made water-tight. Two new spillways were built, at Avalon, which include two tunnels which were excavated in the solid limestone, these two tunnels discharging into the river below. Each of these tunnel spillways is controlled by a cylindrical steel gate of similar design to the one controlling the inlet to the pressure tunnel on the Yuma Project, over which the water flows into the wells and out through the tunnel. In case of heavy floods the gates are raised 10 feet, allowing the water to flow under them, thus increasing the discharge head. The capacity of Spillway No. 1 is about 14,000 cubic feet per second. There are two other spillways with relative capacities of 32,000 and 22,000 cubic feet per second.

Besides these tunnel spillways a reinforced concrete overflow spillway, 397 feet long, was constructed at the west end of the Avalon Dam. This spillway is of circular shape, with a radius of 250 feet. It has a capacity about equal to that of the tunnel spillways.

Lake McMillan, the main reservoir of the system, is formed by a combination earth and rock-fill dam across the Pecos River, 1,686 feet long and 52 feet high, with an embankment 5,200 feet long and 19 feet high, to close the gap in the hills west of the river. The main spillway is cut through rock about a mile west of the dam and discharges into a ravine joining the river two miles below. The reservoir adjoins on the east a bluff of gypsum, very soft and full of seams, and is partially underlaid with gypsum. It developed serious leaks, which gradually increased in magnitude by solution and erosion, until caves and underground conduits were formed of such magnitude as to receive the full ordinary flow of the Pecos River. The capacity below the larger leaks was small, and it became impossible to fill the reservoir except in great floods, and the stored water, even then, speedily escaped. In order to overcome this difficulty the Reclamation Service built a dike to cut off that part of the reservoir in which the main leaks occurred. It is 4,000 feet long and most of it is 19 feet high, and the water-slope is a retaining wall of hand-laid rock on a slope of 1½ to 1, backed with earth. The outer earth slope is 2 to 1, and the earth toe is protected with rock riprap.

In 1914 the dam was visited by a great flood. When the flood was at its maximum the patrol discovered a large leak near the west end. By prompt and energetic action with rocks and earth the dam was saved, and afterwards thoroughly repaired.

Careful surveys have been made to measure the amount of sediment accumulated in the reservoir. It shows an average of about 4,000 acre-feet, so that it is evident in time the reservoir will fill up and new storage capacity must be provided.

The irrigable lands now opened amount to 24,796 acres, of which 166 acres only are public, 923 acres state, and 23,707 acres private land. The building or construction charge per irrigable acre has been fixed for various portions of the project at $31, $45, $55 and $60.

The principal products are alfalfa, cotton, grain-crops, melons, peaches, pears, and miscellaneous fruits, and about 16,000 acres are being actually cultivated.

It can scarcely be expected that, under the conditions here related, the development of this project should have been spectacular or rapid. The aim has been to preserve what had been secured, and to prevent a number of hard working people from losing their hard-earned homes. There has been a marked improvement, however, on nearly all lines, especially on the farms operated by their owners. Cotton has been coming into favour as a paying crop, though alfalfa is the main stand-by. Thousands of tons are fed to live-stock, many cattle and sheep being fat-

Avalon Dam and Spillway
Carlsbad Project, New Mexico

Cement Lined Section Main Canal
Carlsbad Project, New Mexico

tened here, though there is a good dairy industry being developed. There is a co-operative creamery at Otis, which is doing a fairly prosperous business, and the quality of its butter is excellent.

Owing to the occasional occurrence of frosts the peach and other less hardy crops are somewhat uncertain, but the quality of the fruit is far above the average and were packing or canning facilities afforded, would yield good returns to the growers.

The present Project Manager is L. E. Foster, with office at Carlsbad, New Mexico.

CHAPTER XXI

DISAPPOINTMENT AND ABANDONMENT. HONDO PROJECT, NEW MEXICO

Not all battles are won! Sometimes the engineer, even though exercising all of the wisdom acquired by experience, is defeated by the superior forces of nature, especially where he is taken by surprise. There are many cleverly arranged ambuscades which even the best warriors do not detect and nature often cleverly hides for a time some unprecedented conditions. Such has been the case on the Hondo project in New Mexico, where for the present at least the engineers have been foiled in their efforts to store the irregular floods by conditions [illegible] revealed by preliminary investigations.

The principal features of this project are the erratic water supply coming from the mountains, a natural basin offering opportunities for storage of the floods and a topography such that when these flood waters come they are held for a time in the basin, from which they can be taken by a deep cutting and carried to lands partly irrigated and which are highly productive when fully supplied with water. The key to the situation is the reservoir situated above the upper edge of the irrigable lands, amid rolling foot hills and, in a state of nature, with a little lake or pond in the bottom which quickly dried during the heat of summer. It was obvious to every one that if the muddy waters of the Hondo could be turned into this basin and then taken out when needed for the irrigation of the dry lands, great prosperity would follow. The fact that the basin, when filled, would not hold water for any considerable length of time was not discovered until after the reservoir had been constructed, even though preliminary investigation had been made and the experts available at that time had given a favourable verdict on the questions at issue.

Whether or not the preliminary work was sufficiently thorough may be a debatable question but, as a matter of fact, the investment made in this project has not been remunerative and, although the total sum involved is relatively small compared with that invested in other works, yet the inability of this reservoir to hold water has been more widely heralded than the notable successes made with greater and more difficult undertakings!

The Rio Hondo, from which the project receives its name, is formed by the junction of the Rio Bonito and the Rio Ruidoso in Lincoln County, New Mexico, west of the famous "Stake Plains" of Texas. These two streams rise in the Sierra Blanca or White Mountains, about 20 miles apart, and drain the eastern slope of the range, their head waters being protected by the Lincoln Forest Reserve.

The White Mountains are situated about 120 miles west of the project, and have an extreme altitude of 12,000 feet, the highest point in the state, and are well covered with timber. All along the lower reaches of the streams are fertile valleys, and the climatic conditions being favourable, the Mexicans established irrigation farms here many years ago.

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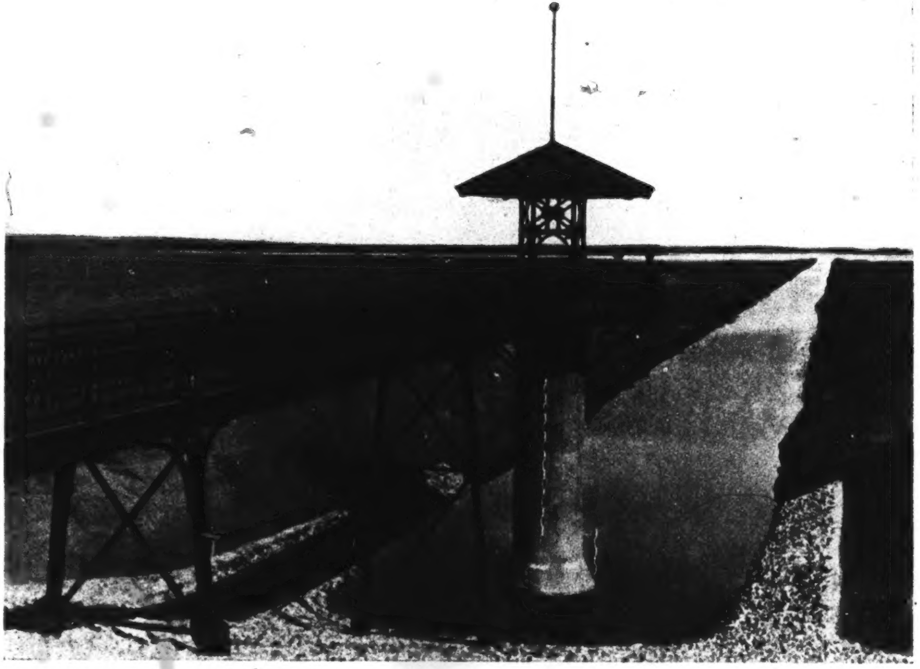
Previous to the year 1869 the Rio Hondo had a perennial flow through its entire course, and at that time the land lying to the southwest and almost adjacent to the present town of Roswell, was cultivated by irrigation from this stream. In 1869 there was a great influx of population into this region, and as Fort Stanton was a military post of some size, affording a ready market for large quantities of forage, grains, vegetables, and fruit, and offering protection from the depredations of the Mescalero Apaches, the available lands along the sources of the Hondo and for fifteen miles along its own course were soon occupied, and the normal flow of the streams fully appropriated.

This flow was fairly to be relied upon in the upper reaches of the two tributary streams during the summer season, but the lower reaches of the Hondo invariably became dry during the late spring and the summer months, except during the periods of flood. The main rains are in the summer and as the country drained by these streams is rough and the canyons exceedingly steep and precipitous the percentage of run-off is very high. Both the Benito and Ruidoso flow through narrow and deep valleys, and the irrigation of their lands, and those of the upper portion of the Hondo, is carried on by ditches taken directly from the rivers, the water being taken by low diversion dams, usually made of brush and loose stones, the flow into the ditches being controlled by wooden headgates.

During the non-irrigating season and the flood periods water flows through the entire course of the Hondo, and, as no more settlers came into the coun-



Hondo Reservoir, looking north from Outlet Tower
Hondo Project, New Mexico

try after about the year 1884, it seemed reasonable to construct ditches along its course for about ten miles west of Roswell, with the idea of appropriating these flood waters so that settlers could "prove up" on their lands. Alfalfa and orchards were planted under these ditches with some success, yet, owing to the intermittent and therefore unreliable flow, the owners were constantly on the lookout for and desirous of securing some means of impounding the water supply.

Out of these desires the New Mexico Reservoir and Irrigation Company was born, in 1888, to give way in 1892 to the Pecos Irrigation and Improvement Company. In that and the succeeding year this company started work on a reservoir, situated at the site of that occupied by the present Hondo Project, but heavy floods in August brought the work to a standstill. These floods carried away the dam of the company at Lake Avalon, on the Pecos River six miles north of Carlsbad, and as it will be recalled that 1893 was the year of a financial panic, no more funds were available and all work ceased.

Yet the site for the reservoir seemed so perfect, being located in a basin—with a small intermittent lake in the bottom—surrounded by hills, which only needed a few embankments to increase its capacity, and the necessities of the farmers were so acute and urgent, that the company succeeded in raising enough money to keep alive its rights, until in 1898, it sold all its rights in Chaves County, New Mexico, which included the Hondo Reservoir site to J. J. Hagerman.

Mr. Hagerman was never able to complete the needful work to give the farmers the relief they required, and yet they "hung on" to their farms and irrigated with the intermittent flow whenever they could, hoping almost against hope that relief would surely come to them in due time.

It was then that the U. S. Reclamation Act was passed. Here seemed a new way of escape. The service was appealed to. In due time preliminary surveys and estimates were made. Various boards of engineers presented favourable reports on the project. It was imperative, owing to the unreliability of the water supply, that the reservoirs have a capacity sufficient to carry water for two or three dry years, and this in turn rendered the question of seepage a most important once. The investigations already made indicated the existence of extensive deposits of seamy limestone and gypsum in the neighbourhood, and these were not considered overfavourable to the location of a large reservoir. The U. S. Geological Survey, therefore, was called upon to send a trained geologist to make a study of the basin as to its power to resist leakage. This was done and the result of the examination (which included diamond drill borings of the site) was that no serious danger of important leakage might be apprehended. On the strength of this report, construction was duly authorized.

The reservoir was increased to a capacity of 40,000 acre-feet by the building of six embankments at various points on the perimeter of the basin, these being riprapped on the water side.

A dam was built of earth, 20 feet high and 100 feet long, to divert the water of the Hondo into a canal, 8,275 feet long, and 70 feet in width at grade, which conveyed it to the reservoir. This canal was designed also as a settling basin for the silt with which the flood waters of the Hondo are heavily laden, and with this in view, the section of the canal is triangular, the side next to the embankment being excavated to a sub-grade four feet below grade.

The lower bank is provided with two spill-gates and five sluice-gates, through which it was designed to scour out the accumulated silt as need required, the silt-laden waters returning thus to the Hondo. A weir was placed at the point of the canal's discharge into the reservoir to encourage the accumulation of silt by permitting only the upper third of the water to discharge.

From the centre of the reservoir the water was led to the Hondo again, through a canal of 10 feet bottom width, 5,300 feet in length. Here it flowed down the river channel, a distance of about a mile, to the edge of the irrigated district.

Owing to the river banks having been built up by the deposits of silt higher than the surrounding country, it was possible to cut ditches at right angles to the course of the stream. Accordingly three low concrete diversion dams, each containing a flash-board frame so arranged that it might be dropped to leave the river channel practically unobstructed, served to throw the water into the four lateral canals. The slope of the surface is so great as to have required the construction of frequent drops in these canals to hold them down to a grade low enough to prevent a cutting velocity. These drops and all similar structures, headworks and the like, are of concrete.

All this work was completed in May, 1907. One can well understand the feelings of joy of the settlers when this announcement of the completion of the project was made. The hopes and fears of the years were at an end. An era of prosperity was now sure, for was not their reservoir ready to receive flood waters, and keep them stored until they were needed? So it seemed. But fate at times plays scurvy tricks upon the sons and daughters of men, and such a trick was now in the cards ready to be dealt.

As soon as the flood-waters began to pour into the reservoir considerable leakage occurred and the quantity of this rapidly increased by the enlargement of holes in the bottom of the basin. Puddling was resorted to and for a short time seemed to be successful. Blasting of the rock by dynamite was also tried, followed by back-filling with carefully selected rock and clay, but the leakages increased instead of diminishing. The more water flowed in the greater became the losses, and fears were gendered that the embankments might be imperilled.

When the outflow increased to 200 cubic feet a second all efforts at prevention and consequent storage were abandoned. The canal system is still used for irrigating such land as can be served by the unregulated flow of the river, but this is so meagre and uncertain that results are very small.

Mr. A. P. Davis thus states his conclusions as to the Hondo Reservoir and its lessons:

The Pecos Valley and vicinity for long distances above and below this point is largely of gypsum formation, and extensive leaks have developed in the reservoir built near Carlsbad in gypsum formation by the Pecos Irrigation Company. It is the author's opinion, not as a geologist but as an engineer, that the depression which constitutes the reservoir site of the Hondo project was formed by the percolation of underground waters through great deposits of gypsum and the gradual solution and erosion of those deposits until extensive caves were formed, which finally collapsed under the weight of the overlying earth and caused a depression or dry lake which formed the site for the reservoir adopted. The lesson is that natural depressions, situated at a distance from natural drainage lines, should be regarded with suspicion, especially when occurring in rock in which caverns may be expected to occur.

Similar experiences, confirming the opinions expressed above, have been had in the case of other similar enterprises within this region of gypsum impregnated rocks. Various cattle companies have endeavoured to build reservoirs and the railroad corporations have constructed large earthen tanks, practically all of which have failed because of the fact that after water has been accumulated in the basins to a certain depth, it has gradually percolated down into the underlying rocks and has broken through the relatively impervious soil or sub-soil. Under a moderate head, several of these reservoirs have been successful for a time, but later have failed either by the "bottom dropping out" and the water escaping through cavities or by the dissolving away of the rock under the dams, permitting these to settle and finally to be destroyed by the rapidly increasing stream.

CHAPTER XXII

TAMING THE RIO GRANDE

THE RIO GRANDE PROJECT—TEXAS

El Rio Grande, El Paso del Norte—what pictures of Spanish *conquistadores* do not these names bring to mind? Coronado and his swashbuckling band of cavaliers and attendant commoners and Indians; Espejo, Oñate and all the *incomers* who expected to find wealth untold in the new land to the north, practically all came from New Spain, Mexico, by way of El Paso and the Rio Grande. Then that swift pouring down the river, of *out goers,* led by the governor of New Mexico, Otermin, after the uprising of the Pueblo Indians in 1680. There were 1,000 of them, men, women, and children, governor, garrison, and three friars who had escaped the slaughter, and they finally camped at what is now El Paso, where for twenty years or more the Franciscans had worshipped at the Mission of Guadalupe. To this uprising and consequent flight of Spaniards we owe the founding of El Paso. The Mission had made of it a placid refuge, now it was established as a presidio for the reconquest and protection of New Mexico.

Long prior to the time of the Spaniards, however, the valley of the Rio Grande had been occupied by the Indians, and the various Pueblo peoples,—those irrigationists of prehistoric times, whose ancestors left long miles of canals also in the Salt River Valley,—had diverted the water into their canals and ditches all along its course, cultivating therewith, in primitive fashion, the grains and vegetables upon which they largely subsisted.

Thus the *conquistadores* found this valley, and it looked good to them after their wearisome miles of desert through which they had travelled from Sonora to reach it. Then, when they themselves took possession of the land, they continued the work and expanded it, until the Anglo-Saxon settler came into Colorado and northern New Mexico. These vigorous and aggressive people, knowing nothing—and possibly caring less—about the fields below that had been cultivated for centuries, and the needs of the Mexican followers of the Spaniard, began to divert the waters for their own use. The more this was done the less water there was for the fields lower down, until it became no uncommon thing for the river to go dry before it reached El Paso, and hundreds of acres that had been cultivated for centuries reverted to their original desert condition.

Hence when the Anglo-Saxon began to elbow the Mexican of the lower Rio Grande he found here scores of miles of old ditches which suggested use for his own benefit. But, though he might start to water the land he lived upon, and succeed in growing crops during the flood season, the flow too often ceased when it was imperative that he have it. And the Mexicans, below the boundary line between the two countries, also suffering in like manner, suits were instituted by the Mexican government against the United States government to prevent the settlers on the American side from using up the whole of the flow.

For the Rio Grande, sometimes, is torrential in its wild floods, and again, it ceases entirely, not a single trickle of water being found in its sandy bed. It rises in Colorado and flows southward the entire length of New Mexico; for a distance of four miles above El Paso, forming the boundary between Texas and New Mexico, then for 1,300 miles it winds its tortuous way, forming the boundary between Texas and Mexico, finally emptying into the Gulf of Mexico. Above El Paso it has a length of about 900 miles, and a drainage area of 38,000 square miles. Its headwaters in the basin of Colorado and New Mexico are found in snow-clad mountain peaks. When the melting time occurs, spring and early summer, the river rises higher and higher, and in the autumn and winter it flows but slightly. The major portion of the New Mexico drainage area is arid and desert in character, and the meagre precipitation is erratic in consequence.

The permanent summer flow of water is entirely appropriated in the upper reaches of the river, leaving for the southern portion of New Mexico little more than the floods which occur at irregular intervals. These used to wash out the temporary dams of brush and rock that were employed, and which could not be rebuilt until the water subsided.

This was the state of affairs when the Reclamation Service was called upon for aid. It was soon evident that permanent dams were required at the head of each of the small valleys that line the river. Indeed it has not inaptly been said that a map of this river appears like a link of irregular-sized sausages, reaching from San Marcial, N. M., to El Paso, Texas.

The International Boundary Commission was also called upon to help solve the problem. It worked out a plan whereby water would be stored in the Rio Grande, by building a dam just above El Paso, which would serve the needs of 50,000 acres of land, more than half of which were on the Mexican side. This plan, however, did not utilize the entire flow of the river, and not only this but it lacked both storage capacity and irrigable land. It furnished no water for irrigating land in New Mexico—where it was largely needed—and at the same time would submerge a large acreage in that State. It was not to be wondered at, therefore, that the project was unhesitatingly condemned by all New Mexicans.

Chief Engineer Davis of the Service had made himself personally familiar with the peculiar hydrographic and other conditions of the Rio Grande River. He knew that the enormous floods which occur do not come with any regularity, and the total flow in some years is less than one-twelfth that of others. The amount of silt carried is excessive, and this would be caught and held by any reservoir, irrespective of its size. With a small reservoir this would soon become a serious problem. He saw, therefore, that it was imperative that the reservoir be as large and deep as possible, so as to minimize evaporation, to have ample capacity for carrying surplus waters from "fat" years to "lean" and a surplus capacity for silt accumulations, so that the sediment would not materially encroach upon the necessary water-storage capacity for many years. Such a site he had found in 1902 in the canyon below Elephant Butte, where a dam could be erected that would back up the water for about forty miles, without submerging any large body of good land or washing out any railroad, and that would give storage capacity for over two million acre-feet of water, capable of irrigating 180,000 acres of land. Later studies revealed that the reservoir could be built so as to hold upward of two and a half million acre-feet of water.

After scientific tests had reasonably demonstrated that this could be accomplished an agreement was made with the Republic of Mexico to deliver it at the Acequia Madre,—the Mexican Canal at the head of the El Paso Valley,—60,000 acre-feet of water annually, Mexico on her part waiving all claims for indemnity for the adverse diversion of the Rio Grande waters. Subsequently the State of Texas became a beneficiary through an enlargement of the Reclamation Law, and an appropriation of a million dollars was especially made by Congress to cover the cost of the Mexican share of building the dam.

It was then decided to build diversion dams at the head of each principal canal along the river, below the large dam, which latter should provide for all their necessities. The demand was found to total 620,000 acre-feet annually, sufficient to irrigate about 155,000 acres and provide for all losses by seepage and evaporation. The Mexican treaty obligations required another 60,000 acre-feet, and allowing a loss of, possibly, 20,000 acre-feet for all water turned out for this purpose, that would make the total annual draft on the Elephant Butte dam amount to 700,000 acre-feet.

The records of the past twenty years show an an-

Elephant Butte Dam
Rio Grande Project, New Mexico-Texas

Country Home in the Mesilla Valley, near Las Cruces,
New Mexico
Rio Grande Project, New Mexico-Texas

nual flow at the reservoir site varying from as low as 200,729 acre-feet in 1902, to 2,422,008 acre-feet in 1905, with four years in succession when the inflow would have been below the needed 700,000 acre-feet, viz., 1899, 239,434; 1900, 467,703; 1901, 656,252; 1902, 200,729 acre-feet. Only in one year, however, would the stored water have fallen perilously low and that would have been in the year 1902 when the inflow was so very low.

Accordingly the Elephant Butte Dam was built. It is a straight gravity structure of cyclopean concrete, with a length of about 1,200 feet. Its height from the lowest foundation to the roadway over the top is about 300 feet, over 90 feet of which is below the river bed. The top width is 20 feet. A spillway lip is provided at the west end, seven feet below the roadway. In addition to this lip spillway, there is also a movable spillway, consisting of four large wells, ten feet in diameter, in the rock bench just up stream from the spillway lip. Each well is closed by a steel cylinder gate which can be raised or lowered at will. Each well merges into a tunnel which passes under the spillway lip and discharges into the channel below. The movable spillways thus provide an additional regulation in time of flood, whether above or below the dam, for, in the latter case, the flow from the dam can be entirely closed until the flood has subsided.

There are twelve regular outlets provided. Those nearest the left bank are ultimately to be used in connection with penstocks for the development of electric-power. There are also *sluicing gates*, as well as the main service gates. All these gates are provided with steel shutters operated by hydraulic power, water being furnished from the large supply tank on the hill which was used during construction.

Large rocks were embedded in the structure to the extent of from 20 to 25 per cent, and its solid contents are in excess of 600,000 cubic yards. For the transportation of men and materials a railroad line, eleven miles long, was constructed to connect at Engel with the Albuquerque and El Paso branch of the Santa Fe.

While the dam was building the river was diverted through a flume built on a bench excavated on the right bank. Where the flume crossed the dam site it was built of concrete and finally incorporated into the dam. The actual cost of the dam was approximately five millions of dollars. It was designed under the direction of Louis C. Hill, and will ever remain as a tribute to his engineering genius and practical skill. The general plan of the project as a whole was due to Director Davis.

The irrigable lands to be served by this dam lie along the Rio Grande in five separate valleys. The first valley, is the Palomas, and it heads about six miles below the dam, with the Rincon Valley about twenty-four miles, the upper Mesilla Valley about sixty-nine miles, the lower Mesilla Valley eighty miles and the El Paso Valley one hundred and twenty miles below the dam. Between these valleys the river flows through comparatively narrow gorges and as a consequence separate diversions and canal systems are necessary for the proper irrigation of each valley.

The first of these dams was built in 1907, at Penasco Rock, and is named the Leasburg Dam, from the old town near by. It supplies the uppermost canal operated at the present time by the Service. The dam is a concrete overflow weir, of ogee section, about nine feet high and 600 feet long, with an extension of 1,500 feet at the west end in the form of an earthen dike. The concrete weir is founded on piling driven into the silt of the river-bed to a depth of 20 to 25 feet. A reinforced concrete apron, 23 feet wide and two feet thick receives the overflow and conducts it harmlessly away from the dam. The west abutment of the dam is founded on piling where it joins the earthen dike. The east or left abutment is founded on rock, the base of "Penasco Rock," a small peninsula jutting out into the river channel. About 80 feet inland from the end of the dam three sluice-gates are placed, each eight feet high with five feet clear openings. Fifteen feet inland from these gates are the gates to the canal, of which there are five, each seven feet high, with five feet width of opening.

From this dam the Leasburg Canal receives the water for three of the community ditches of the Mesilla Valley below. One of the most interesting points about this canal (which is itself a small river) is that it is to be run over a twelve-foot drop, where a turbine will develop electric power equivalent to that of six hundred horses. This will furnish light and power for the Valley towns below, and for the economical irrigation, by electrically driven pumps, of mesa lands in the vicinity of Selden. These lands, like those of the lower Valleys, are wonderfully adapted to the growing of fruits, berries and melons of the finest quality, size and colouring.

The Leasburg Canal, too, is vital to the success of a large proportion of the farmers under the project; for it supplies water for 36,772 acres of irrigable land. Of this, 10,528 acres are under the Dona Ana Community ditch; 7,620 are under the Las Cruces Community ditch, and 14,070 are under the Mesilla Community ditch. In addition to this, it will carry water for the Picacho feed canal to the Picacho flume over the Rio Grande, thus supplying 4,554 acres more.

For another portion of the Mesilla Valley, another dam has been erected southwest of Las Cruces. It is a low diversion weir, 303 feet between abutments, built of concrete with an ogee movable crest, standing two feet above a reinforced concrete apron which covers the river-bed for a distance of eighteen and a half feet up stream from the weir. There is also a concrete apron below the dam to receive the falling water. A movable crest, four and a half feet high, surmounts the weir, in the form of a series of nine radial or "Tainter" gates, to be raised in time of flood to prevent inundation of adjacent lands. A steel bridge surmounts the entire structure and from this the radial gates are operated by means of wire ropes upon drums operated by hand, or by power furnished by an 8-H. P. gasoline engine, carried from one gate to another on a car. The canals head on each side of the river at this dam, the one on the right having a capacity of 430 cubic feet per second, and that on the left 300 cubic feet per second. The canal gates are at right angles to the dam. A sluiceway, 45 feet wide, to clear the gate entrances of mud, is provided at each end of the dam, each controlled by two "Tainter" gates, five and a half feet high, with sills a foot below the crest of the main weir.

The direct highway from the north down to El Paso passes down the east side, crossing the river on this dam. This road connects the towns and supply points of Mesquite, around which are 4,230 acres of irrigable land; Vado, in the neighbourhood of which are 4,016 acres of irrigable land; Berino, with 7,910 acres irrigable, and Anthony, with 920 acres.

In this section, too, are located two of the largest tracts of land under individual ownership that are to be found under the Elephant Butte Project. These are the Brazito and the Santo Tomas Grants. In the Brazito are included about 5,000 acres of land irrigable under the project, with about 2,000 acres of bench lands that may be brought into cultivation by pumping, while the Santo Tomas tract aggregates some 3,500 acres of irrigable area.

At the upper edge of the city of El Paso a diversion dam of masonry was built many years ago. One end of this dam is within the city limits and the other on Mexican soil. This dam has been repaired, and the canal it supplies—called the Franklin—purchased by the Reclamation Service in 1912, for $125,000. In 1914–1915 it was enlarged from a capacity of 150 cubic feet per second to a capacity approximately 400 feet. Through the city of El Paso the greater part of this canal is lined with concrete and protected by an ornamental iron fence.

Of the water users at the present time on the project, approximately 60 per cent are Mexicans and 40 per cent Americans. American ideals of efficiency are gradually supplanting the older indifferent ways and more scientific methods are being adopted for the irrigation and development of the project.

A large variety of crops can be grown and with the excellent markets available can be made to return good profits. The growing season lasts for nine months and irrigation is practised for eleven months of the year. At the present time alfalfa, as is general throughout the West, is the leading crop, approximately 60 per cent of the irrigated acreage being planted to this forage crop. Grains of all kinds, beans, corn, sorghum, canteloupes, deciduous fruits, small fruits, grapes, sweet potatoes, peas, garden truck, in fact nearly all the products of the temperate zone can be grown successfully. Experiments are now being conducted in the growing of cotton and sugar beets, and it is expected that ere long these two products will become leading crops.

The Rio Grande Project is especially adapted to the raising of livestock and this industry has increased rapidly since the water supply has been assured. The mild winters with green feed available a great portion of the year, and summer weather in which there are no periods of excessive heat, combine to make the raising of livestock a most profitable undertaking. During the season of 1915 several hundred head of dairy stock were shipped to the project from the dairy section of Iowa, Wisconsin and Michigan, and nearly every progressive farmer is laying the foundation of a first-class dairy

La Mesa Schoolhouse
Rio Grande Project, New Mexico-Texas

Cutting Alfalfa
Rio Grande Project, New Mexico-Texas

herd. Already dairying has taken a leading place. Poultry farming is also profitable and good markets are available close at hand for all poultry products.

At present the system is capable of irrigating 47,160 acres, and every acre of this is actually signed up. The irrigating season lasts 274 days, from February 15 to November 15. The average elevation of the irrigable lands is 3,700 feet above sea level. The average annual rainfall, computed from the records of thirty years, 10.07 inches. In 1914 it was 17.02 inches. The temperature ranges from zero to 100 degrees Fahr.

The area of the drainage basin is 37,000 square miles. At San Marcial, N. M., the annual run-off in acre-feet, from 1895 to 1914 inclusive, was, maximum, 2,422,000; minimum, 200,700; mean, 1,129,400. At El Paso, Texas, 1889 to 1914 inclusive, maximum, 2,010,000; minimum, 50,700; mean, 925,000.

New canals, etc., are in contemplation for Las Palomas and Rincon Valleys, and the works in the El Paso Valley will be supplemented and enlarged.

The estimated total cost of the project is $10,000,000.

It is contemplated that in due time electric power will be generated at Elephant Butte Dam, which will be used for the pumping of water up to the bench or "mesa" lands lying along the rim of the Valleys, but being too high for irrigation from the gravity canals. In the neighbourhood of Anthony, several owners of small orchards have demonstrated the wonderful value of these mesa lands for fruit-raising, these men having produced peaches, plums, apples, melons, canteloupes, berries, and other fruits and vine-stuff of size, quality, flavour and colouring that cannot be surpassed.

In the neighbourhood of Selden, too, sixteen miles above Las Cruces, and near the Leasburg power drop, is a beautiful acreage of bench land that will be irrigated from electrically-driven pumps, and which will no doubt be found to produce as wonderfully as do those at Anthony. In time, too, this cheap power will be transmitted to the lower Mesilla Valley, in which event, the Anthony lands will be even more valuable than they now are.

In 1905 two Water Users' Associations were formed on the project: The Elephant Butte Water Users' Association of New Mexico, with headquarters at Las Cruces, for lands under the project in New Mexico, and the El Paso Valley Water Users' Association of Texas for lands under the project in Texas.

El Paso, Texas, is the largest city on the project, and it is one of the most rapidly growing cities on the continent.

In New Mexico the towns and cities are Elephant Butte, Hot Springs, Las Palomas, Arrey, Derry, Garfield, Salem, Santa Teresa, Hatch, Rincon, Selden, Leasburg, Donna Ana, Las Cruces, Old Mesilla, Mesilla, Mesilla Park, Mesquite, San Miguel, La Mesa, Chamberino and La Union.

The Project Manager is L. M. Lawson, with office at El Paso, Texas.

CHAPTER XXIII

PUMPING FROM THE MISSOURI RIVER.

THE WILLISTON PROJECT, NORTH DAKOTA

The Williston Project is composed of two units, both of which were designed originally to be separate projects. It was found best, however, to combine them. They are known as the Buford-Trenton and the Williston units. The former is located in Williams County, North Dakota, bordering the north bank of the Missouri River, and includes practically all the land lying between the Great Northern Railway and the Missouri River, for a distance of about 17 miles east of the Montana-North Dakota State line. This entire area was at one time a portion of the Military Reservation of Fort Buford, which post played an important part in the development of the great North-west. The advancement of settlers and the segregation of the Indians made it unnecessary to maintain this post, and it was abandoned in 1895. The reservation was subdivided in 1901, and in 1903 it was opened to entry. There were some settlers within its limits prior to this latter date, and at the close of 1904 approximately 85 per cent of the area embraced within the limits of what is now the Buford-Trenton unit had been entered. Buford is close to the junction of the Yellowstone River with the Missouri.

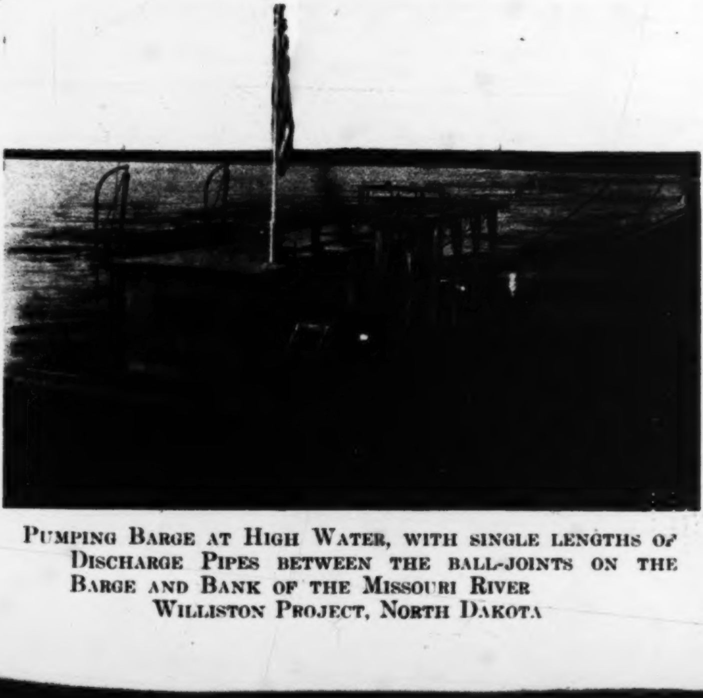
The Williston unit is a few miles away to the north-east, where the Little Muddy flows into the

Missouri, and the irrigable area comprises the bench and bottom lands that are located in the Little Muddy Valley for about twenty miles north of Williston, and the river bottoms along the Missouri River for a distance of about five miles east and west of the city.

There is considerable difference in the characteristics of the lands of both units. The bottom lands of the Little Muddy are very flat, oftentimes being higher next to the creek and for this reason are not as well adapted to irrigation as bench lands, which have some slope. In some locations there is alkali. The bench lands are rather rolling, with frequent knolls and depressions, so that it is not possible to bring the entire acreage under irrigation, and some of the depressions cannot be readily drained. The entire valley is free from brush and supports a growth of bluejoint and other native grasses and in past years has been used for grazing. Beyond the bench lands the land rises rather abruptly for 100 feet or more to the plateau of the Missouri, which extends for many miles on either side of the valley and is cut at frequent intervals by small creeks.

The Missouri River bottoms are quite different in their characteristics. There is an upper and lower terrace, the former devoid of vegetation except a thick growth of grass and the latter covered with brush and scattering timbers. The upper terrace is a heavy loam or clay soil and in places some gumbo. Alkali is not found in a dangerous amount except in a limited area, near Sand Creek, north of the railroad track. The surface is level and smooth and well adapted to irrigation.

Pumping Barge at Low Water on the Missouri River at Williston
Williston Project, North Dakota



Pumping Barge at High Water, with single lengths of Discharge Pipes between the ball-joints on the Barge and Bank of the Missouri River
Williston Project, North Dakota

This portion of North Dakota, in the early geological periods, was included in a great inland sea, in which the successive layers of rock were deposited as sediment, the highest and most recent being generally termed the "Fort Union" beds of sandstone and shale. In time certain portions of this inland lake became silted up and converted into great marshes, which supported a luxuriant growth of vegetation. The trees and plants, as they died year after year and accumulated under water, where they were protected from decay, were, in the course of time, converted into beds of lignite coal, which exist in the vicinity of the Williston Project. One of the most common trees of this period was the poplar, and the sequoia, or redwood, related to the giant trees of the Pacific Coast, was also a native of North Dakota. These deposits of decaying vegetable matter were subsequently covered by later deposits of shale and sandstone, which subjected them to great pressure and resulted in the formation of the coal veins. There is an entire absence of any volcanic or heat action connected with the formation, and this accounts, to a large part, for the low grade of coal to which lignite belongs.

The glacial period covered this portion of the continent with a vast sheet of ice, which started in the vicinity of Hudson Bay and moved in a southwesterly direction up to the present location of the Missouri River. The gradual melting of this vast sheet of ice freed large streams of water, which eroded channels and made decided changes in the earth's surface. One of the larger creeks formed by the melting of this vast ice-sheet is the Little

Muddy Creek, through the Williston unit, and the valley as we see it today is the result of these flood waters, discharging in a southerly direction into the Missouri River. While there is a uniform slope towards the south, there are frequent knolls and depressions, the underlying material being in many places sand and gravel, and it is not until the higher lands are reached that the unmodified glacial drift is encountered. The bottom lands adjacent to the creek are of comparatively more recent formation, caused by silt being deposited during the frequent overflows of the flood discharge of Little Muddy creek.

The bottom lands of the Missouri River are all of recent formation. The river is continually cutting away on the concave curve of the banks and depositing sand and silt on the opposite side. In the gradual change that takes place year after year, the sandbars are left high and dry after the June rise and then the wind begins its action, sweeping along the sand until it is caught among a growth of willows and then we have the beginning of another river bottom, which gradually accumulates a growth, and eventually a soil is formed which is of sufficient depth to class it as agricultural land.

The water for the Williston Project is supplied by the Missouri River which has a drainage basin of 155,000 square miles. The mean run-off at Williston from May to October, 1905 to 1907 was 15,000,000 acre-feet. While there are small creeks that flow into the Little Muddy and the Missouri where the flood waters might be conserved for irrigation, it was impractical anywhere near the location of the lands of this project to divert and utilize them. Accordingly surveys and estimates were made which contemplated the irrigation of the lands by pumping from the Missouri River. This river, however, is an uncertain quantity in more ways than one. Not only does its flow vary, making extraordinary rises and falls in record time, but it often brings down on its flood waters vast quantities of trees and other drift, and, furthermore, the swift floods possess a cutting power, which sometimes eat into the banks as if they were made of soft sugar. These factors of uncertainty, therefore, prohibited the building of any permanent structure for pumping purposes, and the problem was finally solved by the construction of a *floating pumping-barge* carrying the necessary pumping units, with flexible jointed pipes, which would discharge the water into the settling basin on shore. In this way the average fluctuation of from ten to fifteen feet was provided for, and by increasing the length of the discharge pipes the barge could be moored close to the bank or well out in the channel, as occasion required, and could be disconnected at the close of the pumping-season and hauled out on the bank. It was a new idea, in so far as I know, as were many of the features on the pumping projects, and considerable difficulty was experienced in obtaining qualified men to superintend, first, the design, and then the construction of these floating pumping stations.

It was found that lifts were necessary of from 30 to about 100 feet, and the question of cheap fuel for the generation of power then arose. As before explained this whole region is underlaid with lignite.

After many borings and testings, a deposit was discovered near to Williston, which, on thorough testing, proved to be satisfactory as fuel for the generation of power, though conditions were such as to demand the location of the power-plant quite close to the coal deposit.

In due time, therefore, the coal mine was opened, the power-generating plant established, and electrical power then transmitted over wires to pumping-stations, with plans for irrigation as follows: On the Buford-Trenton unit water is pumped from a barge into a settling-basin 30 feet above the river, and is then lifted by a permanent pumping-station into a canal, 50 feet above the settling-basin, for the irrigation of bench lands near Buford. A transmission line 28.3 miles in length delivers power for the operation of the pumps.

The plan of the Williston unit provides for a series of motor-driven centrifugal pumps on a barge in the Missouri River, a settling basin receiving the water from the barge, and a main canal of 90 second-feet capacity extending along the Little Muddy to the power-plant, where two sets of steam-driven turbines operate centrifugal pumps to lift water 51 feet into E canal. From the main canal, about midway between the river and the power-plant, electrically driven pumps raise 35 second-feet 28 feet into B canal, and from this canal 20 second-feet are raised an additional 28 feet into C canal. The main power-station is located close to a 9-foot vein of lignite coal, which supplies the fuel.

In 1916 the Service was prepared to irrigate on the Buford-Trenton unit 4,049 acres, and on the Wil-

U. S. Reclamation Service Coal Mine and Miners
Williston Project, North Dakota

Largest Drop in South Canal
Uncompahgre Project, Colorado

liston unit, 8,189 acres. The irrigation season begins from June 1 to June 15 and lasts about 80 days. The average elevation of the lands of the project is about 1,900 feet above sea level, and the average rainfall about 13 to 14 inches. The range of temperature is from 49° Fahr. below zero to 107° Fahr.

The Williston Project is located on the Great Northern line of railroad, and there are several small villages on the lands besides Buford, Trenton, and Williston, the latter being an incorporated city with about 4,500 population.

The principal products are alfalfa, grains, and vegetables. The production of corn for silage is increasing as well as the output of hogs. Dairying has become well established as the local markets consume all the butter product. Outside markets are St. Paul, Minneapolis, Duluth and Chicago.

As the operation of pumping-plants of this character is an entirely new feature in irrigation it may be interesting to recount a few experiences. The season of 1908 was accompanied by an exceptionally high June rise, with a large amount of drift coming down the river. Trees 4 feet in diameter and 40 feet long smashed into the bow of the barge, giving it severe jolts, and one night caused the mooring lines to part and the barge to be held by the discharge pipes. On the crest of the June rise the cable ferry boat at Mondak came down, struck the bow of the barge and was carried under, without doing any damage except to the ferry boat. Besides floating drift there was a large amount of smaller, submerged drift which would collect in the unscreened suction pipes and clog the pump runners, necessitating removing the upper case of the centrifugal pumps to clean out the drift and other debris. On account of the extremely high water and possible damage to the barge, it was disconnected June 16 to 19 and moored close to the bank.

As many of the lower lands are owned by non-residents, who do not cultivate or lease their lands and who are waiting for the "unearned increment" before they sell, the project has not made as good a showing as it would have done were all the lands put to actual use. There has been considerable dissatisfaction, also, at the construction charge being placed at $38.00 per acre, when the land owners expected it at the original assumption of $25 per acre.

Owing to these conditions the plant was operated for three years at considerable loss to the Service. To provide against such contingencies in future Congress passed an act forbidding the operation of plants that were not reasonably sure of meeting not only maintenance charges but some of the original construction cost, and as the Water Users' Association could not meet the demand of the law for 1916 the project was not operated in 1917.

The city of Williston, however, has been purchasing electric power for lighting and other purposes, so the power plant has been kept in continuous operation.

Conditions seem now to be decidedly improving so that in a short time it is hoped the farmers will be reaping to the full the benefit of the plant installed.

The present Project Manager is W. S. Arthur, with office at Williston, North Dakota.

CHAPTER XXIV

THE LAWTON PROJECT, OKLAHOMA

Seeing the great advantages that had accrued to other localities by the activities of the Reclamation Service certain of the active citizens of Lawton, Oklahoma, conceived the idea of calling upon it to plan for the irrigation of some 2,500 acres of land in the near vicinity of that city.

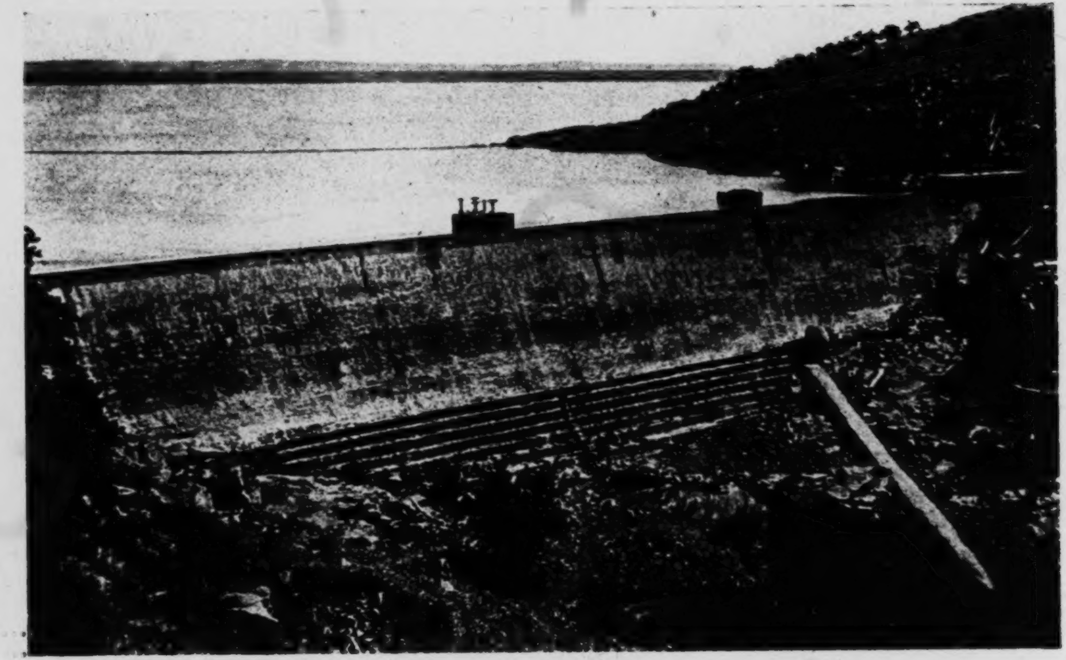
Accordingly, an engineer was sent to study the conditions and report what could be accomplished. He found an adequate water supply in Medicine Bluff and Little Medicine Bluff Creeks, with an area of drainage basin of 110 square miles. The annual run-off at the site of a proposed diversion dam in 1914 was 17,835 acre-feet. The city of Lawton had already created a storage reservoir, Lake Lawtonka, for its own domestic supply of water. It offered the water in the top twenty feet of this reservoir to the Service, provided it would use it for the purpose designated. The lake has an area of 1082 acres, and a capacity of 14,000 acre-feet. The dam is of solid masonry, 50 feet high, and it is estimated that the top 20 feet will give not less than 12,000 acre-feet for irrigation.

The average elevation of the irrigable area is 1,100 feet above sea level, and the length of irrigation season would be from April 1 to October 31—214 days.

The average rainfall in thirty years has been 31 inches; at Lake Lawtonka, in 1914, 28 inches. The temperature ranges from 10 degrees to 110 degrees Fahr., and the climate is similar to that found in the less arid portions of the south-west.

The relatively heavy rainfall would be ample for the production of crops were it well distributed through the crop season. The need of irrigation arises from the fact that severe droughts occur frequently during the early summer. Occasionally, there is a year or several years in succession when there is an ample supply of rain throughout the growing season and then irrigation is unnecessary and the farmers get out of the habit of applying water, ditches are not kept cleaned and the structures fall into decay. Then comes an exceedingly dry year and, before the farmers can rally to get the irrigation system into working order, the plants have wilted and the water when applied is of little use. Because of this irregularity in the seasons and because the farmers are not compelled—as in the arid region—to practise irrigation systematically, practically all of the irrigation ditches formerly utilized in Oklahoma and adjacent semi-arid areas, have been abandoned.

The knowledge of this fact and the further doubt as to whether the relatively heavy soil can be successfully irrigated, has caused the land owners interested to be somewhat slow in mortgaging their lands to build a water supply system which may not be utilized. In other words, while they are enthusiastic about irrigation in general and the increase in prosperity which would ensue, yet when the proposition is definitely presented to each man of his individually guaranteeing its success, each man holds



LAKE LAWTONKA
LAWTON PROJECT, OKLAHOMA

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back from signing up in compliance with the requirements of law and of the executive department.

A distinctive feature of the project is that all the lands are privately owned, hence it was made clear to those interested that the work could be undertaken only upon the conditions laid down by the Secretary when he appropriated $100,000 for the project. These included the formation of some kind of Water Users' Association, or Irrigation District, the members of which should pledge themselves to purchase and use the water for 1,900 acres, which they would divide into small farms, of size approved by the Service, preferably, 40 acres, and dispose of all holdings above that amount at reasonable prices to farmers who would undertake to settle upon the lands and work them, and also that some public land was to be included.

The preliminary surveys revealed a suitable site for the diversion dam on Medicine Bluff Creek, about four and a half miles below Lake Lawtonka, and the final canal location decided upon was surveyed from this point across the Fort Sill Military Reservation. This reservation comprises a large body of land stretching east and west and with its southern boundary about two miles north of Lawton. The proposed plan of reaching the irrigable lands in the vicinity of the city contemplated the diversion at some point in Medicine Bluff Creek below Lake Lawtonka of the released storage supply and whatever unregulated run-off there might be. This diverted water was then to be carried across the artillery range of the reservation in an open canal, for about six miles, reaching the irrigable land at the southern boundary of the reserve. None of the land in the reserve is available for irrigation. North-west of Lawton all of the public land was taken up long ago. Immediately to the north and east, however, the farm and pasture lands of the Fort Sill Indian School are situated, and in order to meet the Secretary's requirement for the inclusion of public land, arrangements were duly made with the Indian Department to add these 600 acres to the private lands available.

It being essential to economic construction and operation that the entire body of irrigable land be located compactly, a tract was chosen next to the Indian lands, but, unfortunately, the Water Users' Association has been able to secure subscriptions to cover only 1,800 acres, and the tracts subscribed were not in a compact body. Accordingly it was determined to form an Irrigation District under the laws of the State of Oklahoma, and enter into a contract for the construction of irrigation works to serve approximately 2,500 acres of private lands.

The land to be irrigated is somewhat rolling and the soil is a clay loam. Products already growing on private lands are garden-truck, melons, tomatoes, cabbages, onions, sweet-potatoes, berries, various fruits, forage crops and cotton. There are ready markets at fair prices locally and at Oklahoma City, Okla.; Kansas City and St. Louis, Mo.; Galveston, Texas; and New Orleans, La. The population of Lawton in January, 1915, was estimated at 8,000. It is located on both the St. Louis and San Francisco and the Chicago, Rock Island and Pacific Railways.

The present Project Manager is H. M. Schilling, with office at Lawton, Oklahoma.

CHAPTER XXV

"WHERE ROLLS THE OREGON." THE UMATILLA PROJECT, OREGON

As early as 1896, Mr. A. P. Davis (now Director of the United States Reclamation Service), established a gauging station on the Umatilla River, at Gibbon, Oregon. Data were being accumulated for the use of the new Service—that designed for reclaiming, by irrigation, the lands of the arid or semi-arid West.

In 1905 the Oregon legislature, awake to the great advantages of practical irrigation, passed an irrigation act, which provided, among other good things, for the appointment of a State Engineer, and for coöperation with the United States in hydrographic and topographic surveys and the construction of works for the development and use of the waters of the State.

During the summer of 1905 investigations disclosed the likelihood of a successful project being established east of the Umatilla River. A basin offering fair storage possibilities was found in Cold Springs Canyon, and below this site there were some 20,000 acres of irrigable land at an elevation of from 350 to 550 feet above sea level.

The Umatilla River is a tributary of the Columbia and drains an area of about 2,000 square miles. It has a mean annual run-off of over 500,000 acre-feet, a large part of which is diverted by numerous canals and ditches and used for irrigation by private enterprise. The main run-off is in the winter and spring and no efforts had been made to provide storage to supply the deficiency of flow invariably experienced in the growing season of summer.

There was no suitable site found on the river itself for a storage dam, and the site in Cold Springs Canyon was the only feasible one that was discovered, hence plans were prepared, and in 1906 the work of actual construction commenced. They provided for a feed canal, which necessitated a diversion dam on the Umatilla River, two miles above Echo. The canal, 24½ miles in length, is to convey the water to the reservoir made by the storage dam at Cold Springs Canyon, from whence it is conveyed by the distributing system to the lands to be irrigated, in all about 25,000 acres, half of which were privately owned.

The diversion dam in the Umatilla River is provided with a concrete overflow weir 400 feet long and three feet high, founded on a timber crib three feet deep and twenty-three feet wide, filled with rock, forming an apron upon which the overflow falls. Sheet piling is driven at the lower and upper edges of the crib. There are eight cast-iron headgates, with sills two feet below the crest of the weir. They are separated by reinforced concrete piers, and these piers are connected by curtain walls above the gates, so that no water can flow over the gates. An ingenious method of sluicing the canal near the headgates is also provided.

The feed canal leading from the diversion dam to the reservoir has a maximum capacity of 350 second-feet. Much of it is lined with concrete for safety and for economy of water. This lining is mainly four inches thick, a small part, however, being only two inches.

About half a mile before the feed canal reaches the reservoir, a by-pass chute is provided, by which water can be dropped down the hill into the distribution canal system about 60 feet lower. This is a concrete chute of trapezoidal section with a stilling basin at the bottom.

At the discharge of the canal into the reservoir a large concrete drop is built to prevent back-cutting along the canal. A short distance above its outlet, the canal is provided with a set of gates in the form of flap valves which remain open as long as the water is flowing towards the reservoir, but close when a current starts in the opposite direction. This prevents back-flow when the reservoir is full, and the feed canal supply is stopped.

The Cold Springs Dam is located about six miles east of Hermiston. It is essentially an earth and gravel embankment, having an extreme length of over 3,800 feet, and a maximum height of 98 feet. The greatest depth of water is about 88 feet, and the depth over the outlet-conduit when water starts to flow over the spillway crest is 61½ feet. The dam is composed of a mixture of loam and coarse sand and gravel, mixed in the proportion of about one-third loam to two-thirds sand and gravel. Great care was taken to obtain a thorough and compact mixture.

The outlet conduit is located on bedrock a little south of the centre of the canyon, about seventeen feet above its bottom. The outflow is controlled from a tower built in the reservoir upon bed-rock at the upper end of the conduit, and reached from a bridge extending from the top of the dam. In this tower are installed two cast-iron sluice-gates, each four feet square, placed in series, one at the outside of the gate-tower and the other at the inside, the former being an emergency gate, and the latter used in ordinary service.

The outlet conduit is built of reinforced concrete and is of horseshoe cross-section, six feet wide and five feet high, with cut-off collars at intervals of thirty feet. It discharges into a rock-cut canal which has a capacity of 225 cubic feet per second.

A spillway is provided on the right bank just above the dam. Its concrete overflow lip is 330 feet in length and is eight feet lower than the crest of the dam. After spilling over the crest the water glides down a concrete slope into a concrete-lined channel at right angles to the dam, becoming larger and deeper until it discharges into the canyon below the dam. With a head of three feet, this spillway will discharge about 5,900 second-feet, leaving five feet freeboard on the dam; this with the storage of three feet on the surface of the reservoir will take care of the largest flood known with a good margin to spare.

The water-distribution system of the Umatilla Project is extremely complicated on account of the character of the topography and sandy soil. Many pressure-pipes were necessary to reach isolated tracts or to cross depressions, and the open sandy soil required the lining of many canals and laterals to avoid excessive seepage losses. At first some doubt existed as to the kind of pipe to be used. Wood pipe was admitted to be the cheapest in first cost, but since it would be in use only about seven months and dry for the remaining five months of each year, its life would be short. Steel pipe was expensive in first cost, and there was also some doubt as to its length of life in the peculiar soil of these lands. Hence it was decided to experiment with concrete pipe, which after many tests and several years of active use has proven very successful. The methods of manufacture and construction followed are of value wherever such work is required. Many drops and chutes were also necessary to deliver water safely from higher to lower levels.

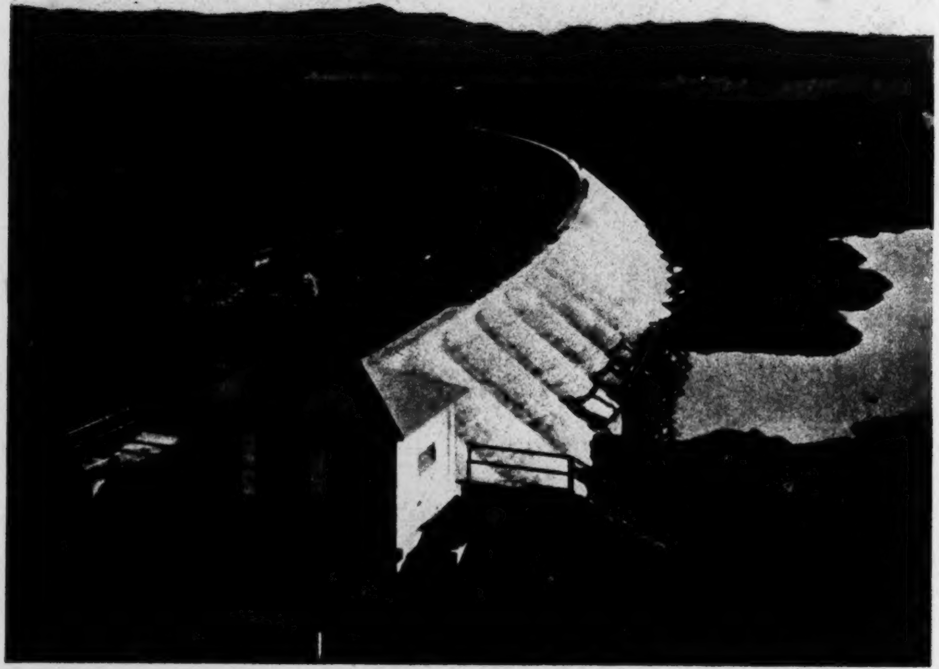
The losses of water from canals and laterals and the large quantity escaping into the subsoil on the farms brought up the ground water-table on the lower lands; soon bogs and ponds began to appear and gradually to enlarge. This condition was aggravated by the absence of natural drainage lines and the existence of isolated depressions which are so characteristic of a topography formed by wind. In fact, but little of the lost water was able to reach the river except through the subsoil. To correct the seepage and prevent its spread, about ten miles of open drainage channels were excavated. The drainage thus secured into the Umatilla River exceeds 60 cubic feet per second in the summer, and forms the major portion of the water-supply available for diversion to irrigate the west extension of the project, which will later be discussed and described.

The area reached by the main canals consists of about 25,000 acres, lying in a compact body, which may be stated as the entire irrigable area south of the Columbia and east of the Umatilla rivers lying north of the feed canal and west of Cold Springs Reservoir, with the exception of about 1,200 acres near Umatilla. About half of this land was patented to private owners before the work of the Service began; the other half was either public or entered under the Desert Land Act.

The distribution system consists of a main distributing canal from the reservoir from which minor distributaries draw; also a main canal which diverts from the Umatilla River near the mouth of Butter Creek, reaches the irrigable lands in a distance of two and a half miles, and eight miles further completely merges into the system from the reservoir. The last named canal was formerly owned by the Maxwell Land and Irrigation Company and was acquired by the United States by purchase.

The first water for irrigation was turned on the land March 25, 1908, for the first unit of 6,975 acres. The second unit, of 4,392 acres, was opened the latter part of March, 1909. The third unit, of 3,952 acres, was opened on March 15, 1910. On May 1, 1911, the reservoir was filled for the first time, water passing over the spillway. In 1911 the fourth unit, of 1,976 acres, was opened March 21.

When the project was begun the country was practically a complete desert. Where Hermiston is now located there were then only three or four buildings. Perhaps half a dozen residences were seen over the irrigable area. During the year 1908 development of the First Unit was slow. The season was unfavourable on account of severe and persistent



Three Miles Falls Dam
Umatilla Project, Oregon

winds, which lasted from early spring until well into June and made it difficult to start growth. Again, the large area held by desert land entrymen and the Maxwell Land & Irrigation Company retarded development. Little improvement was done on desert land entries, and only a small portion of Maxwell land was sold.

During the year 1909 additional efforts were made to improve desert land entries. Sale of Maxwell lands were, however, sluggish. There were a number of homesteads in the Second Unit, but a considerable portion of those who filed sold their relinquishments without attempting to improve. No great effort was made to improve the entries until fall. Since then fair progress has been made.

Prior to the passage of the Reclamation Act the land now embraced in the Umatilla Project had little value. As soon as surveys were made by the Reclamation Service, or by private parties, and it became evident that there was a prospect that the land might be irrigated, land prices increased. About 1904 the Maxwell Land & Irrigation Company bought several hundred acres from the Northern Pacific Railway Company for approximately $4.50 per acre. In 1904 the County Assessor appraised raw land in the project at $3.00 per acre. In 1906 certain school land changed hands for about $14.00 per acre. After water was available some of this land sold, unimproved, for about $85 per acre.

Before water was available for the First Unit the Northern Pacific Railway Company sold about 150 acres of raw land, located one mile from the railroad station at Hermiston, for $90 per acre. This land was subsequently resold for $125 per acre. About the same time the Maxwell Land & Irrigation Company sold raw land at from $75 to $80 per acre. Later they sold raw land one mile from the railroad station at $175 per acre. During 1910 and 1911 raw land four or five miles from the railroad station was sold at $200 per acre. In the Third Unit the Northern Pacific Company sold fully 700 acres of unimproved land at about $100 per acre. The foregoing figures do not include the cost of a water-right. During the latter part of 1911, and during 1912 few sales were made and prices dropped.

While the plans of the main project were thus being successfully carried out, surveys were also being made looking towards the supplying of water to some 40,000 acres of land west of the Umatilla River. Various plans were proposed, but the one most feasible appeared to be that now to be described, capable of watering 30,000 acres, at an estimated cost of about $100 per acre.

The plan was approved in March, 1912, contingent on satisfactory arrangements being made with not less than 95 per cent of the private lands involved. When these arrangements were perfected construction began, and the work is now largely completed.

This west extension takes water from the Umatilla River, on the left bank, below all other important diversions, and is designed to irrigate lands in the Columbia River near Irrigon and westward. The water-supply consists mainly of the return flow from the main project and adjacent irrigated lands and is deemed ample for about 10,000 acres of land. This area could be enlarged by several thousand acres by the conversion of a nearby valley into another reservoir. The diversion dam is known as the Three-Mile Falls Diversion Dam, and it receives its name from the low water-fall there existing which is distant about three miles from the Columbia River.

It is located about half-way between Hermiston and Umatilla on the Umatilla River. It is the only dam of its kind in the whole of the works of the Reclamation Service, in that it is of multiple arch design, the axis being curved to a radius of 1,200 feet. There are forty arches resting against buttresses which are twenty feet centre to centre. The arches are one foot thick at the crest, and increase in thickness downward at the rate of one-half inch for every foot vertical. The outer face of each arch is curved to a radius of eighteen feet, and the inner face to a radius varying from sixteen to seventeen feet, according to thickness. The maximum height of the dam above the river-bed is twenty-four feet. A back wall traverses the entire length of the dam except a distance of one hundred and eighty feet in the river section. The total length of the dam is nine hundred and twenty feet, width of maximum section thirty-four feet.

The buttresses are of concrete, eighteen inches thick and are reinforced with two parallel vertical tiers of half inch steel spaced two feet apart. The crest of the dam is four feet wide and spans the space between buttresses as an arch of sixteen foot radius, heavily reinforced by half inch rods spaced six inches apart each way. An inspection gallery runs the length of the higher part of the dam and greatly stiffens it.

The headworks of the canal are located on the left bank of the river at the west abutment of the dam and are at right angles to the axis of the dam. There are three gate openings, each five feet wide and six feet high, operated in a 12 foot by 20 foot concrete gatehouse. Here a concrete highway bridge spans the canal. Just below the bridge are ten revolving fish screens, installed between piers.

The sandy soil and coarse subsoil of the lands of the west extension, together with the experience with similar conditions on the east side led to the decision that the entire canal and distribution system, from the very outset, should consist of concrete channels. The lining of canal and the manufacture and installation of concrete pipes therefore became even more important than on the eastern division.

The main supply of the water, as I have shown, comes from the Umatilla River, whose headwaters are in the Blue Mountains, which extend north and south, to the eastward, and stretch into southern Washington. When the snowfall here is heavy the water flow is correspondingly increased, though other conditions also have to be considered. When the snowfall is not well packed, or there is an early spring the run-off is exceedingly rapid, and where, combined with these two factors, there is a limited fall a short water flow may be anticipated.

The average elevation of the irrigable lands on the project is four hundred feet above sea level. The average annual rainfall is 8.3 inches, though in 1914 only 6.6 inches fell. The range of temperature is great, extending from 28 degrees Fahr. below zero, to 115 degrees Fahr.; though it is seldom the thermometer goes below zero.

While to those who do not like the strongly marked differences of temperature between the four seasons this climate will not be attractive, there are those to whom it is stimulating, invigorating and almost perpetually pleasing. Now and again there are severe winds, which generally blow during the months of March and April. The sharp tang of winter is free from the penetrating cold of a more humid atmosphere, as there is rarely any wind in winter and no place can be more healthful and life-giving.

The principal crop is alfalfa, the maximum yield reported being about eight tons to the acre. Much of this is baled and shipped, and some is fed. There is an increasing number of dairy stock on the project and the creamery at Hermiston is ready to purchase at fair prices all the butter-fat it can obtain.

Hogs and poultry do well, as many as three thousand of the former being marketed in one year.

Most of the vegetables and fruits are successfully grown, and apples, peaches and apricots of delicious flavour thrive abundantly, although now and again the frosts injure the early peaches. Strawberries and all bush berries flourish.

Grains for forage and milling and especially acclimatized corn have made a most gratifying showing. Four first prizes were won one year at the State Corn Show. Watermelons and canteloupes were recently introduced and they are proving to be one of the most profitable of crops, the latter vying with the famous Rocky Fords, of Colorado, in juiciness and flavour. Bees also do well and produce a very fine grade of honey in fairly large quantities.

The Umatilla Project has passed through nine years of experience that have given it a firm footing, have removed obstacles, and corrected legal impediments that contributed to its adversities. Its settlement began during the Bacchanalian orgies of high prices for land and great profits from fruit that swept the great Northwest several years ago. The first people caught by the alluring offers came largely from the cities, without farming experience and with little means. They were doctors, lawyers, clerks, mechanics, brokers, and the ne'er-do-wells. They knew styles, had soft hands and flabby muscles, were full of hope, knew nothing much of physical hardships, and were ambitious without real power. Most of them, however, as times have tried them, have proven themselves honest and courageous.

But the game was hard for them. They bought land at fabulous prices, paid an instalment and started the battle against interest and reduction of principal. They agreed to pay off the government water-right, too, in ten years. They bargained to improve the land, to make a living, to pay off the water-charges and to pay for the land while they grew an orchard on ten acres that requires seven to ten years to bring to a profit-producing stage. This condenses into a short paragraph the stern, hard, and losing battle many of the settlers fought for four or five years. At the end of this period there were no soft hands or flabby muscles. Some of the people left financially broke and mentally defeated.

Others capitalized their experiences and tackled the game again with renewed energy and new determination.

They planted alfalfa and borrowed money to buy cows and hogs. They planted gardens, raised poultry, and honey, and did other things that brought quick returns. One doctor, an excellent citizen, worked on the roads for money to buy groceries, like many others. But it turned the tide. The Government extended the water payments to twenty years and gave other relief. In the meantime the price of raw land tumbled and new people began to buy and develop places that supplied work for many deserving settlers. For the last four years alfalfa areas have increased, more and better cattle have added fertility and dollars, and the various features of diversified and intensified farming have been added, to the great benefit of the farmers.

The project now has several hundred experienced farmers, the values of unimproved lands are low, water payments easy, there is no long wait for a fruit crop, but quick returns and a living after one year. Had these conditions prevailed nine years ago the Umatilla Project today would have been a garden from corner to corner. This it is sure to become ere long as hope has given way to assurance and practically every farmer now knows that his certain prosperity is close at hand.

Another step forward was taken when, in response to earnest solicitations from the settlers, the State established the Umatilla Experiment Station. A practical, as well as scientifically educated, farmer is in charge, and he is ready at all times to aid settlers.

The Service also has sent some of its expert field men to help them solve their problems.

A fine illustration of the broadly helpful principles that control the direction of the work of the Reclamation Service is found in the supplying of water, for power purposes, to Joseph Cunha, of Echo. The main canal ran near enough to suggest to him the possibility of securing a more steady and continuous flow of water, and permit the abandonment of his individual parallel ditch. Negotiations were entered into, offers and plans made, which were finally accepted by Mr. Cunha, and now the Echo Flour Mill is operated by this water, and the project is so much to the good through a beneficial arrangement with one of Oregon's citizens.

The leading town on the project is Hermiston, with a population of 650. It is a growing and fairly prosperous frontier town, with all that goes to make life in a farming community comfortable and pleasing. The outside population on the project is about 1000.

The farm unit of the public lands is twenty to forty acres, but there are only twenty units not filed upon. The remainder of the lands are in private ownership. The construction charge is $70 an acre, on the older portion of the project and $92 an acre for the west extension, payable in twenty years without interest. The annual maintenance and operation charges are small, but varying in accordance with amount of water used.

The Project Manager is Herbert D. Newell, with office at Hermiston, Oregon.

CHAPTER XXVI

AMONG TULE MARSHES AND LAKES. THE KLAMATH PROJECT, OREGON–CALIFORNIA

On the boundary line between Oregon and California are vast tule marshes thousands of acres in extent, in which several open lakes of large area are found. These are connected with each other by a network of creeks and rivers. Surrounding and adjacent to these tule lands, which are merely shallow lakes, are other thousands of acres of slightly higher land above the water level and which, from their fertile character, attracted the attention of the early settlers who came to this portion of Oregon in the early 'fifties. The region is now known as the Klamath country.

The abundant water supply coming from the high mountains, the level character of much of the land, the fertile soil resulting from the decay of the volcanic rocks, all attracted the attention of the engineers. The tule marshes especially aroused interest because of the fact that swampy lands similar in appearance had been successfully reclaimed in the Sacramento Valley; it was early assumed that these tule covered swamps, if drained, must necessarily be extremely fertile. Here, however, has been involved one of those popular fallacies which, though often exposed, is hard to destroy: because certain marshes have been reclaimed and have produced wonderful crops, therefore, all other marshes should be reclaimed! As a matter of fact, it is now known that not all of the swampy and overflowed lands possess a soil such that when drained, it can be economically subdued. Such has proved to be the case with some of the Klamath lands, especially those of the lower lake. On the other hand, the soil under the Tule Lake, in many ways similar in appearance, is capable of producing large crops.

The area embraced in the Klamath Project is a large and somewhat varied tract of country located about midway between San Francisco, Calif., and Portland, Oregon, and 150 miles east from the Pacific Ocean. It is generally known as the Klamath Basin, receiving its name from a tribe of Indians that still inhabit some portions of it. It is on the eastern side of the Cascade Range, and has an elevation of from 4,000 to 4,200 feet above the sea. Two large valleys, the Klamath and Lost River, constitute the greater part of its area, amounting in the aggregate to approximately one-third of a million acres, not all of which, however, is reclaimable. The portion to which the Service directed its attention is a square, the sides of which are about 50 miles long, and located approximately at the corner common to Modoc and Siskiyou Counties, California, and the northerly boundary of Klamath County, Oregon.

At the outset it was decided to employ Upper Klamath and Clear Lakes as the two reservoirs of the project, with Horse Fly Lake as an auxiliary in case it should be needed. Upper Klamath Lake is a natural reservoir with an area of 60,000 acres and a storage capacity of 140,000 acre-feet, without the construction of regulating works. It receives the drainage from a watershed area of 100 square miles and its principal tributaries are the Sprague, Williamson and Wood Rivers, these rivers draining the regions easterly and northerly from the lake. Williamson and Wood Rivers are fed by some very large springs, the water supply probably coming in large part from the Crater Lake region. The Upper Klamath Lake acts as an immense regulating basin and discharges into Link or Klamath River over a rimrock, serving as a natural weir, the discharge varying between 1,000 and 10,000 second-feet, the mean discharge being 3,400 second-feet.

Clear Lake receives the drainage from a watershed area of approximately 600 square miles, the principal feeder being Willow Creek, which drains a considerable area of mountainous country west of Goose Lake. The area of the lake originally was about 10,000 acres with approximately 5,000 additional acres of marginal swamp lands. A dam 33 feet high makes possible a storage of 462,000 acre-feet, the reservoir thus formed covering an area of approximately 25,000 acres. The discharge of Willow Creek varies from 2 second-feet to 6,000 second-feet, the heaviest run-off occurring in the months of March and April.

Horse Fly Reservoir is located on Miller Creek, a tributary of Lost River at an elevation of approximately 4,800 feet and has a drainage area above it roughly estimated at 200 square miles. The reservoir basin is flat and swampy with an estimated valley area of 3,500 acres, a large proportion of the land being public. The creek, with a discharge varying from 2 second-feet to 6,000 second-feet, flows through a narrow canyon of basaltic rock at the dam site; and a dam 50 feet high would impound approximately 123,000 acre-feet. This site is of substantial importance.

In addition to the lake areas mentioned above as serving for storage reservoirs there are two others, Lower Klamath, and Tule, within the project limits, for which reclamation by drainage was planned. Of this, more will be said later. Lower Klamath covers an area of 29,400 acres, or including the marginal swamps, an area of 88,300 acres; while Tule Lake covers 96,000 acres of which it was hoped ultimately to reclaim 35,000 acres.

The climate in the Klamath Basin is mild, with the summers warm and dry, but not excessively hot. Snow falls during the winter, but extreme low temperatures are rare. The rainfall is light averaging from 10 to 12 inches; the land therefore requires irrigation, and without it, few crops can be raised with certainty. The cool climate permits the growth of grain, alfalfa and the hardier vegetables, but limits the cultivating of the more delicate fruits and vegetables.

The preliminary reconnaissances of the engineers seemed to confirm the optimistic prognostications of the settlers. Here were thousands of acres of good land, millions of gallons of unused water, thousands of acres of swampy land covered with tules. Elsewhere tule-marsh land had been drained and reclaimed and found to be fabulously rich for agricultural purposes; why should it not be so here? True, there was considerable alkali, both black and white,

Looking up Klamath River, Oregon, east of Keno, over the Tule and swamp lands, 1905
Klamath Project, Oregon-California

which had come to the surface where careless or over-irrigation had been practised, but alkali elsewhere had been leached out, hence why not here?

There were already four or five private canal systems, irrigating in the aggregate a considerable area, and capable of covering much more land, properly handled, and the soil experts sent out by the government wrote favourably of the possibilities of the soil, hence it was an enthusiastic and optimistic audience of farmers that met the officials of the Reclamation Service in Klamath Falls in November, 1904.

One result of this meeting was that numerous petitions from farmers and others (one with nearly 300 signatures of ranchers, merchants, professional men, county officials, etc., of Klamath Falls, Merrill, Bonanza, and the adjacent valleys), were received by the Secretary of the Interior, urging that the Service undertake the work.

There were several seemingly unsurmountable difficulties to be overcome ere this could be done. These were the vested and conflicting water rights that had already been obtained under state laws to be adjudicated. Many settlers owned riparian rights on Lower Klamath and Tule Lakes; these must be surrendered or future trouble was sure to arise. The states of Oregon and California must cede the ownership of Lower Klamath and Tule Lakes to the United States Government and enact laws which would permit the lowering or raising of their waters, and, finally, the United States Congress must give to the Secretary of the Interior power to destroy the navigability of these waters.

Such was the enthusiasm brought to bear upon the work by newspapers, and state and federal officials that in a few months all these difficulties were, in the main, overcome.

Now everything seemed clear for going ahead. The estimated extent of the project, roughly classified into Upper Valleys with 48,356 acres, Klamath Basin, 140,797 acres, Tule Lake Bed, 47,248 acres, was a total of 236,401 acres. Here was where a serious mistake was made. Too many acres were included in the possible reclaimable area, and this naturally lowered the estimate of the average cost of construction per acre. The farmers, however, did not understand, or if they did, they wilfully ignored any possibility of future revision of these figures.

Everything appearing to be favourable, the project was duly recommended, and on May 15, 1905, the Secretary approved of it, allotting $4,400,000 for its completion, one million dollars of which was immediately available.

One of the earliest tasks that met the Service was the purchase of existing works and canals, and the reconciling of conflicting interests. To merely recount the efforts expended in these matters would occupy many pages. Suffice it to say that through litigations, compromise, conferences, and purchase the main rights ultimately became vested in the Government.

In 1906 various surveys were made, one of which was for the purpose of determining the amount of fall available for power purposes on the Klamath River below Keno, and ultimately a canal was built on the west bank of the Klamath River, diverting water from the river 1,200 feet from its outlet from Upper Klamath Lake, with the intention of using it for power purposes. As yet, however, no plant has been installed, as all irrigation at present is by gravity flow. A power plant will be put in later, without question.

It is well, before the irrigation plan is presented, to secure a fairly clear idea of the complicated system of lakes and rivers of this region and their curious relations to each other. Upper Klamath Lake is a large body of fresh water, fed by mountain streams, and is approximately forty miles long and six miles wide. At the southerly end of this lake is a rock barrier, over which the water discharges in a series of rapids, falling about 56 feet, thence through the marsh of the lower edge of Lower Klamath Lake, thence over another barrier of rock, and then by rapid descent to the ocean.

The connection between the Lower and Upper Klamath Lakes is very small, and the Lower Lake has a limited drainage directly tributary to it but is connected naturally with the Klamath River by a narrow slough. During the season of high water this slough carries water from Klamath River to the lake, and when the freshets have passed and the level of the river declines, the current of the slough is reversed and it carries water from the lake to the river. Thus the stage of the lake follows tardily that of the river.

Clear Lake bears a similar relation to Lost River and its upper feeder, Willow Creek. When the latter was in freshet it overflowed into Clear Lake, which discharged its surplus water through Lost

River. Lost River follows a circuitous course and discharges into Tule Lake, which has no visible outlet, but disposes of its water by evaporation and seepage. It normally covers an area of about 90,000 acres, which fluctuates with the varying discharges of different years and cycles of years.

The area of the drainage basin comprises 37,000 square miles, with an average annual rainfall on the irrigable area of 14.2 inches. The average elevation is 4,100 feet above sea level, and the temperature ranges from -10° to 100° Fahr. The annual run-off in acre-feet, from 1904 to 1913, at the River at Klamath Falls was, maximum, 2,530,000; minimum, 1,450,000; mean, 1,770,000. Lost River and Willow Creek at Clear Lake, maximum, 255,000; minimum, 35,000; mean, 125,000. Lost River at Olene and Merrill, maximum, 475,000; minimum, 15,000; mean, 265,000. In 1916 the area for which the Service was prepared to supply water was 47,600 acres, of which applications were signed for 27,254 acres. The irrigation season extends from May 1 to September 30—153 days.

The systems of irrigation in existence when the Reclamation Act was signed included the so-called Ankeny Ditch—the Klamath Falls Irrigating Co., which had diverted water from Upper Klamath Lake for over twenty years. It occupied a strategic position at the outlet of the lake and had water rights covering 1799 acres of land.

In 1902 a filing was made on the Upper Klamath Lake, at the head of Link River, for 30,000 miners' inches of water. This was subsequently enlarged to 150,000 miners' inches, which included the whole flow of the Link River, and a company known as the Klamath Canal Company organized. Its object was to irrigate on a large scale the land of the Klamath and adjoining valleys. This company also filed on the waters of Miller Creek and Lost River, and also secured an option on the property of the Summit Lake Irrigation Company.

For over 20 years the so-called Adams Canal had been supplying water from the Lower Klamath Lake to the pioneers who had settled in the vicinity of Merrill, Oregon, to the extent of about 8,000 acres. This was the Little Klamath Water Ditch Co., and it consisted of 22 miles of main canal.

Near to Clear Lake the Jesse D. Carr Land and Livestock Company owned 15,000 acres of swamp and meadow land, and this was needed for the Reservoir site. It also controlled riparian land around the lake amounting to approximately 10,000 acres more, and owned 7,000 acres of irrigable land along the north shore of Tule Lake.

On the west side of Link River, Moore Bros. owned two small canals starting near the head of the rapids. These canals were in the way of the Keno Canal, which was contemplated for power and irrigation purposes, so an amicable arrangement was entered into whereby the Moores exchanged their property and rights for 205 second-feet of water delivered from the Keno Canal.

All the above rights, canals and lands were purchased and thus the Service had a clear field. Its completed plan provides for the use of the Upper Klamath and Clear Lakes for storage purposes. The natural outlet of the Upper Klamath is the

Link River, and water for irrigation is diverted from its east side, 700 feet from the lake, into the main canal, which extends 9 miles in a southeasterly direction. From Lost River water is diverted to the Griffith Canal at the Lost River Dam, 10 miles southeast from Klamath Falls, Oregon. This supplies the Adams Canal.

Clear Lake Dam and dikes were built mainly to withhold the waters of Lost River from Tule Lake into which that river empties. The water thus stored is released into Lost River whenever needed for irrigation. It is proposed to reclaim about 30,000 acres of the bed of Tule Lake by evaporation. To assist in this, the Lost River Diversion Dam and Canal—8 miles long—were built to divert the flood waters of Lost River into Klamath River. The present irrigation system consists of 210 miles of canals and laterals and 53 miles of open drains. These works cover the total irrigable area of 47,660 acres.

As the reclamation of the bed of Tule Lake progresses, a second diversion dam will be built in Lost River about 15 miles nearly south from the first dam. This will divert water east and west on the reclaimed area of the lake bed.

The principal features of the project are the Clear Lake Reservoir, Lost River Diversion Works, the Keno Power Canal, the Main Canal Tunnel, 3,300 feet in length, and the main canals of the distributing system.

The Main Canal heads in Upper Klamath Lake. The head-works consist of 6 steel gates set in concrete, each 5 feet wide and 8 feet high, separated by piers 2 feet thick, with grooves for flash boards so that the gates can be unwatered for examination or repair. The capacity at low water is about 1,000 cubic feet per second.

The canal for about 2,700 feet is in a deep cut, 13½ feet in bottom width, lined with concrete 6 inches thick. It then enters the concrete lined tunnel, which is of the same width, and rectangular except for an arched top. About 9 miles below the head-works is a large lateral known as the South Branch Canal.

To exclude the waters of Lost River from Tule Lake—the marshes of which it is proposed to reclaim—the regulating reservoir of Clear Lake was built, and the regulated waters are diverted by a dam near Wilson's Bridge into a channel with a capacity of 350 cubic feet per second, and carried thereby to Klamath River. In this way only the flood waters of Lost River exceeding the above capacity are allowed to reach Tule Lake. The storage dam at Clear Lake is a combination of earth and rock-fill. It is 33 feet high. It has a core-wall only at the base. The area of the reservoir formed is about 25,000 acres, and has so far disposed of all surplus water by evaporation and seepage, and this supply is thereby eliminated from Tule Lake.

The Lost River Diversion Dam near Wilson's Bridge is of unique design. It was necessary to raise the water nearly to the elevation of the flood plain in order to make the diversion channel feasible. On the other hand, the water must not be permitted to much exceed the same level in flood times lest it overflow valuable lands in the valley above, which has a very flat gradient. It thus became necessary to provide a long overflow weir with movable crest, to afford the necessary discharge at the permissible head. To secure this, the dam was designed in plan to be of the shape of an elongated horseshoe with the toe up-stream. This causes the overflow to fall in the interior of the horseshoe, and thus to dissipate its surplus energy in opposing currents and whirlpools before leaving the solid concrete structure, which it leaves very placidly. A similar length of weir across the valley would have involved a large amount of excavation to carry the structure down to suitable foundation, besides requiring expensive provisions for conducting the overflow harmlessly to the natural channel below.

The Keno Power Canal was constructed to supply a prior power right, to give additional power and supply water for irrigation. The water is taken from the Upper Klamath Lake to a point 6,200 feet below, just opposite the town of Klamath Falls, where a drop of 50 feet is obtained. A discharge of 200 cubic feet per second here disposed of the prior right, but as the canal has a capacity of 600 cubic feet there are great future power possibilities as yet unused.

The power canal has an overflow weir to dispose of surplus waters incident to the fluctuating demands of the power-plant. The necessary length of overfall was obtained by building the weir in a series of rectangles.

When it came to the work of reclaiming the marshes—which seemed such a comparatively simple matter at the beginning of the project,—several

INTAKE GATES OF MAIN CANAL
KLAMATH PROJECT, OREGON-CALIFORNIA

LOST RIVER DAM
KLAMATH PROJECT, OREGON-CALIFORNIA

serious obstacles presented themselves. To keep water from flowing into Lower Klamath Lake, the embankment of the railway that has been built from the main line of the Southern Pacific at Weed, California, through Klamath Falls, to Kirk, Oregon, was used as a levee. A culvert was provided through this levee, with provision for controlling the flow in either direction. The river and lake were closed to navigation, and a small part of the northwest area of Lower Klamath Lake was diked off and unwatered by pumping. Drain ditches were provided to control the ground water and crops were planted. Now arose the unforeseen. The soil, that was expected to be rich and fertile, was found to be intractable. An agreement had been entered into with the Bureau of Plant Industry of the Department of Agriculture to establish an experimental farm for ascertaining the best method of draining and subduing the marsh lands, and determining the crops best suited for their cultivation. It was found that the raw tule mat was very tough, and hard to reduce quickly into good tilth. In order to have at least a small piece of land in good condition for cultivation, the furrow slice was removed from about one acre. After this was done, it was found possible to work up the next layer into a very good tilth for a seed bed.

In the spring of 1910, after arrangements had been made to bring to the land a supply of fresh irrigation water, a number of grain and grass crops together with a series of vegetable crops, were planted.

The major portion of all the crops planted came up, and commenced growth in a fairly satisfactory manner, although the seedling growth was slow. Irrigation water was used freely in an effort to reduce the salt content by leaching. After passing the seedling stage, most of the plants began to show symptoms of distress, manifested by arrested growth and yellowing. In general it seemed that the tender crops came up promptly, but after having exhausted the food supply stored in the seed, they began to suffer and die, although temperature and moisture conditions were favourable to growth. The wheat, oats, barley, alsike, clover, alfalfa and redtop remained alive throughout the season on the diked land, but none of these crops made anything like a normal growth.

None of the crops in the foregoing list gave any indication of ability to thrive under the conditions of the experiment; and it became apparent that thorough leaching of the land would be a necessary preliminary to the production of any of the ordinary crop plants.

When the drainage of the experimental tract was first undertaken, a large number of curbed open wells were dug for the purpose of observing the rate of recession of the ground water. With the beginning of the crop season of 1910, observations were begun as to the depth of the water in these open wells, and samples of the water were tested from time to time with the electrolytic bridge to determine the salt content. The necessary instruments were also installed to observe the air temperature, wind velocity, and the temperature of the seed bed.

Chemical analyses showed the presence in the soil and water of large quantities of soluble salts, chiefly carbonates of sodium, calcium, and magnesium, in other words, lime and black alkali. Repeated and various experiments were made in an effort to leach out these salts. All went to show that the downward and lateral movement of the water into the land was so slow as to make very doubtful the possibility of reclaiming the land by leaching out the excess of alkaline salts.

Further investigation revealed that there was far less deposition of rock sediment or silt to mix with the aquatic vegetation than had been supposed, hence the marsh lands were lacking in essential elements of fertility. Furthermore, the decomposition of the aquatic vegetation furthered the development of black alkali. The study of the problem of evaporation of this vast body of water showed also that the conditions are such that low temperatures and killing frosts were likely to occur during every month of the year, thus limiting the possible crops to the hardier species.

And thus the matter practically stands today. The farmers of the region cannot believe that these marsh lands are fundamentally different from other marsh lands, and yet no way has yet been found to make them profitable under cultivation. Hence further reclamation must be undertaken with caution to prevent unproductive expenditures.

On the remainder of the lands of the project, however, conditions are generally favourable. Alfalfa, timothy, alsike, red and white clover, redtop, and orchard grass are the principal hay crops. Some sweet clover is grown on lands not well suited to the other grasses and experimental plots of Sudan grass have yielded well. Alfalfa does well on all lands where there is sufficient depth of soil. Alsike clover and redtop grow better on the shallower soils and on those partially seeded. Considerable areas were sown in grains in 1915 and in 1916 owing to high prices prevailing; the yield for 1915 was generally good for wheat, oats, barley, and rye. The season of 1916 was late with heavy frosts late in June, which lowered the yield for that season. Rutabagas, sugar beets, and potatoes yield well, though late frosts sometimes injure the potatoes. Fruits and berries do well and each farm can raise sufficient for home use without trouble. In some favoured localities apples do well, and peaches, plums, prunes, and cherries are grown to a small extent. Pears do well and yield heavily. Owing to the elevation and consequent late frosts it can not be considered a fruit country.

The average return per acre on the 27,254 acres irrigated in 1915 was $13.85, and while some individual farmers have had a rather hard time, the general air of the region is one of fairly contented prosperity. The growth of the city of Klamath Falls may be regarded as an index to the development of the country. In 1904 it had a population of less than 500, now it numbers over 6,000.

When the Service entered the district there was a small area of land under irrigation from privately owned canals, on which alfalfa lands were held at a value of from $20 to $30 per acre. Choice dry land in the surrounding country sold for $5 or $6 per acre. At the present time lands under Government Canals sell for from $50 to $100 per acre, depending upon location; and dry lands adjacent are being sold at from $10 to $20 per acre. The general increase in land values since the first operations of the Reclamation Service has been from 100 per cent to 300 per cent.

In conclusion it will readily be recognized that this project has demonstrated the fact that it was one that only the Government could have experimented with and developed as far as has been done. Mere interest charges would have swamped private capital. It has presented, and still presents, complex problems. It has not only irrigation and drainage problems, but an evaporation and run-off problem, any one of which is difficult in itself, but all of which taken together form a most perplexing whole. In nearly all Reclamation projects, whether of the Government or private owners, water has to be conserved. Here, however, there is more than enough, and one of the great questions is how to get rid of it.

The cost charges per acre on the different units are as follows: First unit, $30 per acre; Second unit, $30 per acre; Third unit, $39 and $45 per acre.

The present Project Manager is J. B. Bond, with office at Klamath Falls, Oregon.

CHAPTER XXVII

HELPING PREVENT MISSISSIPPI VALLEY FLOODS. THE BELLE FOURCHE PROJECT, SOUTH DAKOTA

As early as 1903 *The Northwest Post,* published in South Dakota, called attention to the wisdom of the citizens of Butte County selecting several reservoir sites for the consideration of the engineers of the Reclamation Service. Among other things the editor said:

> Going north we find Owl, Indian, Antelope, Battle, Four Mile, Moreau, Sand, and North Moreau Creeks, where floods regularly occur. The little Missouri and Grand rivers are available for irrigating large areas of the north part of the county; and last, but not least, if the vast volume of water carried off by the Belle Fourche River was stored until needed for irrigation, it would supply a large area along both sides of its valley. The Redwater River being already appropriated to its full capacity, it is not available, unless the Government should take over the rights of the present appropriators.
>
> In looking over the hydrographic situation in this county, we find that if the water supply of the county could be conserved, it would be ample for our needs, while as it now is it does us no good, and causes no end of trouble and expense to our neighbours along the lower Mississippi.

Already private enterprise was in the field. Fully $100,000 had been expended in constructing earthwork dams for the storage of water, but the greater possibilities of the flood-waters of the Belle Fourche River were too great to undertake. Accordingly in April, 1903, the citizens of Butte County forwarded a petition to the Secretary of the Interior setting forth the following facts, viz.: that Butte County, South Dakota, comprises 7,689 square miles (larger than the whole state of New Jersey); that the flood-waters of the Belle Fourche River if conserved would reclaim large tracts of arid lands at small expense; that suitable reservoir sites existed, and that the major portion of the irrigable lands were public.

As the result of this petition careful reconnaissances were made of the region, and although exact data upon the water run-off of the country were not available, it seemed reasonable to plan for the diversion of the Belle Fourche River a short distance below the mouth of the Redwater into a large conduit which should convey it to a reservoir to be constructed on Owl Creek at its junction with Dry Creek, about eight miles in an air-line from the diversion point, from whence it could be canaled to irrigate large tracts of land on both sides of the river as far east as Willow Creek on the north and Butte Creek on the south.

The Belle Fourche River drains an area of about 4,300 square miles in western South Dakota and eastern Wyoming, including the northern slope of the Black Hills. The discharge of the river occurs mostly in the spring and early summer months, it being relatively low in the late summer and fall. Hence irrigation on a large scale could be based only upon the storage of a full season's supply. Photographs taken locally prior to the advent of the Service showed the Belle Fourche at flood evidently pouring forth considerable waste water. This it was determined to arrest and store until needed. Measurements made from 1903 to 1915 have since given the following facts: The annual run-off, in acre-feet, maximum, 554,608; minimum, 119,860; mean, 315,359.

The lands to be irrigated looked first-class, and the engineer of soils recommended that the farm unit be limited to 40 acres. This was afterwards raised to 80 acres. The area in 1916 for which the Service was prepared to supply water was 78,591 acres, and there were applications signed for 61,313 acres. The length of the irrigation season is from May 1 to October 1—152 days, and the average rainfall 14.5 inches. In 1915 it reached 21.44 inches. The average elevation of the irrigable area is 2,800 feet above the sea, and its temperature varies from -30° to 103° Fahr.

The diversion dam on the Belle Fourche River is about 1½ miles below the town of Belle Fourche. It is a concrete weir 23 feet in height and 400 feet long between abutments, with 900 feet of earth embankments. Beyond the north abutment are located the sluiceway and the intake for the inlet canal. This canal is 6½ miles long and has a capacity of 1,600 second-feet. It is located on the north bank of the river and extends from the intake in an easterly direction through the divide to Dry Creek, where the water passes by a 10-foot drop into the reservoir. The terminus of the canal is protected by a semicircular concrete weir, 180 feet long, founded on shale, with a maximum depth of 2 feet of water over its crest at full canal discharge.

BELLE FOURCHE DIVERSION DAM
BELLE FOURCHE PROJECT, SOUTH DAKOTA

About half a mile below the intake the canal crosses Crow Creek, a stream which is dry during the larger portion of the year, but which has a drainage area of about 130 square miles, and carries, during the flood season, a large amount of unappropriated water which is available for storage. It was decided to take this water into the canal, and to guard against damage from excessive floods, a concrete overflow weir 180 feet long was designed. In this weir are three sluice-gates, 5 x 10 feet each, with sills below the grade of the canal, to sluice out the mud washed in by Crow Creek.

The main storage reservoir is formed by an earthen dam 6,493 feet long, with a maximum height of about 115 feet. It is one of the largest earthen dams in the United States. The reservoir covers over 8,000 acres at high water, and has a capacity of about 200,000 acre-feet, or 65 billion gallons. With such an enormous storage, and the attendant possibility of an appalling disaster should a break occur in the embankment, it was essential that the most thorough and careful consideration be given to insure its perfect safety. The material below the damsite was thoroughly prospected and found to be highly desirable. A cut-off trench was excavated the entire length of the dam to a depth of from five to twenty feet, ten feet wide on the bottom. This was refilled with selected material in 4-inch layers, wetted and rolled. Additional trenches were provided in the wider portions of the base. The clay for the embankment was carefully chosen so that it did not include soluble salts, which would destroy its impervious qualities. As fast as it was put into place it was wetted and then rolled with 21-ton traction engines.

The water-slope of the dam for a short distance above the toe is 5 to 1, this flat slope being near the bottom and unprotected against wave action. Higher up, however, it was necessary to secure the dam against the effect of waves. At times this is a stormy region, the wind attaining a high velocity, and waves under such conditions are created that can wreak considerable havoc. When it is also recalled that in winter-time the ice-sheet is several feet in thickness and consequently possess great thrusting force, it was decided to pave the dam with concrete blocks, each about a ton and a half in weight, bedded in gravel to prevent slipping. These blocks were 6½ feet long, 5 feet wide, and 8 inches thick, and they were laid with exceeding care, so as to form a smooth and perfect surface. Sixteen thousand of them were put into place before the dam was completed.

The need for these was soon to be apparent. On the night of April 13, 1912, when there were about 100,000 acre-feet in the reservoir, a high wind from the west arose, estimated at 70 miles an hour, which caused waves in the reservoir 8 to 10 feet in height to beat against the concreted slope of the dam. During the fiercest attacks the dam seemed to bear all onslaughts without injury until, at the final culmination of the storm, between midnight and 4 A. M. of April 14, the receding waves periodically relieved the weight of the face of the concrete blocks, so that the *back-pressure of the water behind the blocks* displaced several of them on the seventeenth course.

This permitted the waves to act upon their gravel foundation and gradually undermined the blocks above as far up the slopes as the waves could act, and also laterally to a great extent, allowing the blocks to slide down, thus forming an irregular pavement. About 250 blocks were thus removed as well as the gravel behind them. None, however, were broken. A careful study of these results of the storm led the engineers to believe that had the blocks been twice as wide—up and down—as they were, or had they been fastened to the courses above and below, the accident could not have happened. All the blocks had been laid with vertical joints broken, so that each corner of a block was at a three-way joint. Therefore, to prevent a similar injury, at each of these joints a 1½-inch hole was drilled, and this hole filled with grout to act as a bond, or tie, holding the blocks together.

But another, and severer, storm in May, 1916, when the wind blew at approximately 65 miles an hour, demonstrated that the precautions thus taken were inadequate. There was much more water in the reservoir, and the twenty-second course of blocks was the one attacked. To prevent future disaster, the blocks in the danger zone have been removed and replaced, the length extending up and down the slope instead of horizontally, and cement-mortared at all points.

A slight seepage was discovered down stream after the reservoir was placed in service, but a small drain was provided which has proven effective.

The North Canal is about 45 miles long and heads at the north outlet conduit. Its capacity is 1,600 cubic-feet per second to the wasteway channel which it crosses half a mile from the dam, and here are located spillway gates. Below this point the capacity is 650 cubic-feet per second, the bottom width is 28 feet, and the water depth 7 feet.

About 8 miles from the head of the North Canal, just before crossing Indian Creek, it is provided with a sluiceway, and a drop of 36 feet into Indian Creek, by which the water can be quickly turned out of the canal in case of a break. The water is discharged by the sluice into Indian Creek at about 200 feet above the flume crossing. This flume across Indian Creek is 43 feet above the creek-bed, and 1,300 feet long. It is built of galvanized steel and supported on wooden bents, anchored to concrete bases.

In order to avoid building a lateral parallel to the main canal, the farm units along the canal are mostly provided with a separate turn-out, consisting of a 12-inch vitrified clay-pipe with concrete inlet and outlet, controlled by a steel gate working in a steel frame, and moved by means of a screw stem inclined 20 degrees from the vertical. Most of these outlets are 12 inches in diameter.

The South Canal heads at the south outlet of the Belle Fourche Reservoir, and runs in a southerly and easterly direction, a total length of about 45 miles. It furnishes water to 4,000 acres west of Owl Creek, and to 28,000 acres south of the Belle Fourche River. The canal crosses the river by means of a pressure pipe or inverted siphon, 3,565 feet in length, working under a maximum head of 65 feet, and an average head of 50 feet. It is built of reinforced concrete and has an internal diameter of five feet. The shell is 8 inches thick, and is reinforced with 305,000 pounds of ½-inch and ⅝-inch steel bars. The inlet and outlet structures are both of reinforced concrete, the former being protected by a steel grizzly to prevent the entrance of drift.

About two miles east of the river-crossing the canal passes through a high bluff, through a tunnel, 1,306 feet in length. It is horseshoe in shape, and has a maximum width of 9½ feet, and a centre width of 10½ feet. It is timbered throughout.

The South Canal is carried across Anderson Draw by means of a reinforced concrete pressure pipe 425 feet long, under a head of about 45 feet, and under Whitewood Creek by means of another concrete pipe 350 feet long, under a head of 15 feet.

The distribution system includes 400 miles of lateral canals, and over 1,000 small structures. It is designed to deliver water to each unit of 80 acres or larger, and to carry a cubic foot per second to each 30 acres, with a minimum canal capacity of 4 cubic feet per second, so that by rotation every irrigator can use that head of water if he chooses.

In the earlier years of work on the project there was the usual rush of settlers to gain possession of land, but from 1912 to 1916 there seemed to be a lull. The first six months of 1916, however, showed fresh interest, until now there are but 56 unentered farm units on the project.

Steadily the settlers have advanced towards greater prosperity and comfort. The conditions of life on the project are reasonably favourable and are constantly improving.

The town of Belle Fourche, the highest point in the district, has an altitude of 3,000 feet, and in plain sight above the city are the Black Hills, shouldering their way thousands of feet into the air. Harney's Peak, rising 7,216 feet, is part of the range, and is the highest peak in the state.

A delightful climate, with an abundance of sunshine is found in the Belle Fourche Valley. The air is clear and pure, and attracts attention by its exhilarating effect. The rainfall occurs largely in May and June, after which a long season of fair weather may be depended upon. The nights are always cool. Pleasant weather lasts until late in the fall, the earliest frosts occur usually about October 1. During the winter there is little snow and no great amount of cold weather, and more or less work is done in the fields all through the season. The minimum temperature is 38° below zero. The sudden breaking up of winter is a noticeable feature of the climate.

In the early part of 1910 the Chicago & North Western Railway Co. constructed a line from Belle Fourche to Newell, S. D., a distance of 23 miles. Three new towns were started along this line as follows: Fruitdale, S. D., a village with a present population of about 150, located a distance of 8.5 miles east of Belle Fourche. Nisland, S. D., located between Fruitdale and Newell, along the Belle Fourche River, is a growing little town and practically all lines of business are represented there. The population at present is around 250. The town being situated in the heart of the older settled portion of the project is rapidly becoming one of the

Placing the Concrete Blocks on upstream face of Belle Fourche Dam
Belle Fourche Project, South Dakota

Spillway at Head of Waste Channel, north end of Belle Fourche Dam
Belle Fourche Project, South Dakota

most important shipping points of the project for grain and livestock, also alfalfa hay. Dairying is being undertaken by a large number of farmers and shipments of butter fat are increasing at a good rate. Newell, S. D., the government town, is the present terminus of the Chicago & North Western Railway, and is located in the centre of the irrigation project. The town is now a little over six years old, and has a population of about 400. It is surrounded by 40 acre farm units. Shipments of hogs, cattle, sheep, forage, grain and butter show a steady increase. In addition to the growth and development of the irrigated area, the increase in shipments is due to the location of the town. It being the eastern terminus of the railroad naturally draws to it all shipments from the open range to the north and east. It has been demonstrated that sugar beets can be successfully grown in this vicinity and tests made show that the beets are of superior quality for the manufacture of sugar.

Throughout the valley timber is found along the borders of the streams, and hardy trees and shrubs grow luxuriantly wherever water is supplied. Orchards of hardy fruits, such as apples, plums, and cherries, do fairly well with proper care.

There is an abundant underground water supply in the Belle Fourche district. Borings of from 500 to 3,000 feet reach flowing water and the supply is apparently unlimited throughout the upper part of the valley. Belle Fourche is furnished with excellent water from three artesian wells flowing into a 50,000 gallon tank. There are also a number of private artesian wells within the city limits. The higher lying lands in the lower part of the valley at present depend on cistern and canal water for domestic use.

The wide valleys and rolling hills of the Belle Fourche district offer two distinct kinds of soil; that on the south side of the river is a sandy loam, that on the north a heavy clay. Throughout the region there is a large amount of rough land. This land, too high for irrigation, has been divided as nearly equal as possible among the different farm units. It is suitable chiefly for grazing purposes, with here and there areas on which dry crops may be produced. All the soil is extremely fertile, cultivation is easy and no hard pan is found. In years when the rainfall is sufficient, fine crops can be raised in the valley, but a crop cannot be depended upon without irrigation.

In the low-lying lands of creek and river bottoms, tall wheat grass and native hay grow abundantly, and these crops sell at high prices. The level upland stretches outside the project are dotted with cattle and sheep grazing on the nutritious wild grasses that cover the prairies. Thousands of acres of alfalfa, of which three crops may be cut in a season, furnish one of the principal products. All the cereals, including corn, are grown, the fields yielding from 20 to 75 bushels per acre. While the quality of the potatoes grown bespeaks for them a place on every farm, the sandy soil south of the river is especially well adapted to the growth of this crop. Sugar beets raised here contain a large content (18.5 per cent) of sugar. Agreements to plant out 2,300 acres have been signed for 1917, and a sugar factory is promised for 1918.

The vast open country surrounding the valley to the north, east and west, affords pasturage for large herds, making this one of the best cattle ranges in the United States. As many as 5,000 carloads of cattle have been shipped from Belle Fourche, S. D., in a year. Large flocks of sheep also feed on the ranges, and immense quantities of wool are shipped annually from this region.

The raising of hogs is rapidly becoming one of the principal industries. Large quantities of alfalfa, barley, and feed corn are produced in the valley, and owing to the dry atmosphere, diseases peculiar to the hog are uncommon. Poultry raising is profitable as there is a constant demand for eggs as well as chickens.

The climate, the richly nutritious native grasses, and the easily grown alfalfa, make ideal conditions for dairying. With the convenient market for dairy products offered in the mining towns of the Black Hills, dairying is rapidly becoming one of the leading industries. A well equipped creamery at Belle Fourche, S. D., is doing a good, substantial business.

Fruits and vegetables raised in the valley can be sold in the mining camps of the Black Hills, where employment is given to thousands of men. Deadwood, Lead, and other of these busy mining towns are only about 40 miles distant from the centre of the project. Milk, eggs, butter, poultry and garden-truck all bring good returns, and there is a constant and growing demand for these farm products.

Sturgis, Whitewood, Belle Fourche, and other towns have direct railroad connection over the Chicago & North Western Ry. with Omaha, Sioux City, St. Paul, Minneapolis, Chicago and other large cities.

The present population on the project is about 4,200. About 15,000 acres remain to be furnished with distributing laterals. The construction cost has been fixed at $30, $40, and $45 per acre, payable in twenty years without interest.

The present Project Manager is B. E. Hayden with office at Newell, South Dakota.

CHAPTER XXVIII

IN MORMON LAND.

THE STRAWBERRY VALLEY PROJECT, UTAH

The Strawberry Valley Project is located in the counties of Utah and Wasatch, Utah, and it receives its name from the location of its reservoir. Its source of water supply is the Strawberry and Spanish Fork rivers, and a number of small streams and springs not on the watersheds of these two. Strawberry River has a drainage area, including Indian and Trail Hollow creeks, of 175 square miles, while Spanish Fork River's area is 670 square miles.

With an average elevation of the irrigable area at about 4,600 feet above sea level, and a temperature that ranges from 10° to 95° Fahr. it can well be seen that its agricultural and horticultural products are somewhat limited, being in the main alfalfa, hay, cereals, sugar beets, and the hardier fruits and vegetables.

The soil is excellent, as a rule, being sandy loam, heavy clay, and a varying mixture of both; black alluvium; loam and gravel. Much of it is underlaid by a coarse gravel, and the natural drainage is excellent.

The irrigation plan of the Strawberry Valley Project provides for the storage of water in the reservoir on Strawberry River; the discharge of the stored water through the Strawberry Tunnel driven through the Wasatch Mountains, approximately three and three-quarters miles long, into Diamond Fork, a tributary of Spanish Fork River; and the diversion of water from Spanish Fork River into canal systems, watering lands east and south of Utah Lake. A hydro-electric plant on the south side of the river three and one-quarter miles below the diversion dam supplies power for construction and commercial purposes. Part of the power developed will ultimately be used for pumping water for irrigation of high lands and drainage of low lands. The United States claims all waste, seepage, unappropriated spring and percolating water arising within the project, and proposes to use such water in connection therewith, as it does on all of its projects.

The Strawberry Valley Project will furnish a full or partial water right to a total area of about 70,000 acres located in Utah County. Part of this area has a flood water right from Spanish Fork River, but on account of the supply being low after July 1st, only certain early crops could be raised. A part of this area will need one-fourth of a water right, a part one-half of a water right, and about 30,000 acres a full water right from the project. All but about 4,000 acres of the land is in private ownership.

This section of Utah was settled first about 1850 and was developed as far as practicable with the water supply. A generation has been born and raised on this land, but the young folks have had to go elsewhere for land as there was no water to irrigate more land here. With the advent of the Straw-

West Portal of Strawberry Tunnel, Four miles long
Strawberry Valley Project, Utah

berry water there will be an abundant supply for a large acreage and while the average holding at present is less than 40 acres, the present indications are that divisions of the land will bring the individual holdings to less than 20 acres within a short time. Many new settlers have come in during the past year and the benefit from the project may be considered general.

The Government land located in the Goshen Valley that is to be irrigated will be opened for entry during the latter part of 1917, and with the opening up of this area, and the area of private land that has already been cultivated as dry farms on the west end of the project, a sufficient new population will be brought in to support a town located about 8 miles west of Payson.

As yet no lands have been opened for irrigation by public notice, the major part of the most available having been occupied in private ownership long before the project was contemplated.

The project includes the following units: Spanish Fork, Lake Shore, Mapleton and High Line units; Clinton, Soldier Fork and Diamond Fork districts; the difference between a unit and a district being as follows:

A *unit* is a section of the project on which water is sold to private individuals under the same terms and conditions to all, each individual executing a water right application mortgaging the land for the water, the water being supplied to the unit from the project water supply. A *district* designates an area on the upper branches of the Spanish Fork River to which water is sold under the Warren Act, all the water users signing one contract, the Government agreeing to turn certain water into the river for this district and the district in turn trading this water to the owners of old rights on the lower part of the river for the privilege of diverting water from the upper branches of the river that was originally used on the lower land, as for instance,—the Spanish Fork and High Line units are irrigated from water directly from the water supply available for the project. The Clinton District is located on the upper branches of the Spanish Fork River above the source of supply, and while they cannot get any project water, they can buy it and trade it for some of the old water rights in the Spanish Fork River and divert it onto their lands. This scheme was devised for the purpose of assisting in the further development of a number of old settled districts on the upper part of the Spanish Fork River that did not have a sufficient water right of their own, having settled on the land after the water was filed on by canals lower down. By arranging thus to sell them water, and allowing them to exchange it, they were enabled to divert the water that they had always had to allow to flow by, for the use of lower lands.

The Spanish Fork Unit. This unit is made up of about 31,000 acres of land located on both sides of the Spanish Fork River in the vicinity of the town of Spanish Fork. The greater part of this area has a flood-water right from the Spanish Fork River and is irrigated by four existing canals, and during March and April contracts were entered into with them as follows:

Spanish Fork East Bench Irrigation & Manufac-

Power-house and Wasteway Chute
Strawberry Valley Project, Utah

Bridge across Wasteway at north end of Strawberry Dam
Strawberry Valley Project, Utah

turing Company, March 25, 1915; Spanish Fork South Field Irrigation Company, March 25, 1915; Spanish Fork Southeast Irrigation Company, April 25, 1915; Spanish Fork West Field Irrigation Company, March 25, 1915.

In these contracts these companies agreed to deliver through their canal systems any water that might be sold from the Strawberry Valley Project to lands that could be irrigated from their canals, a reasonable charge to be made for such carriage and such extension of the system as might be necessary, due to the delivery of this water.

On June 30, water-right applications, numbering 266, had been executed on this unit, covering an area of approximately 5,600 acres, and on June 27 the delivery of stored water was commenced to the land that had signed water-right applications under the Spanish Fork East Bench Irrigation & Manufacturing Co., under this unit.

Lake Shore Unit. The Lake Shore unit covers an area of about 6,000 acres of low land located on the west side of the Spanish Fork River on the shore of Utah Lake. It is irrigated from the Lake Shore Canal, which has a fair flood-water right in the Spanish Fork River. After considerable negotiations a contract, dated October 12, 1914, was entered into with the Lake Shore Co., in which they agreed to deliver through their canal system any water that might be sold from the Strawberry Valley Project to lands that are irrigated under the Lake Shore Canal, a reasonable charge to be made for such carriage. The price per acre-foot on this unit is $45, the same as on the Spanish Fork unit, with the schedule of delivery and other conditions practically the same. On June 30, an adequate number of water-right applications had been received on this unit, covering an area of approximately 1,500 acres, and the delivery of a flow of 8 second-feet of storage water was commenced on June 27, 1915.

Mapleton Unit. This unit covers an area of about 4,500 acres located on the east side of the project on the Mapleton Bench, a large part of the area having a partial water right from Hobble Creek. The landowners submitted a petition stating that they desired to purchase water for between 3,000 and 4,000 acres of land, and after considerable negotiating a form of water-right application was approved similar to the one approved for the Lake Shore unit, but on presenting the water-right application to the landowners only a small part of the acreage represented by the petition executed a water-right application. On March 19 the committee submitted a petition asking that the construction of the Mapleton lateral be commenced, but, after considering all phases of the matter, decision was reached that it was not advisable to undertake the construction of the lateral until additional land had been signed up and the conditions imposed by the Secretary had been fulfilled. The lateral necessary to supply this land with water is rather costly, due to the several expensive structures necessary to bring it across the Spanish Fork Canyon and the double-track main line of the Denver & Rio Grande Railroad.

High Line Unit. This has an area of 25,000 acres, the greater part of which at present has no water right. This will be irrigated, a complete canal sys-

PEACH ORCHARD ONE YEAR OLD ON MAPLETON BENCH. WASATCH MOUNTAINS IN THE BACKGROUND
STRAWBERRY VALLEY PROJECT, UTAH

tem will be constructed by the Reclamation Service, and on the Spanish Fork and Lake Shore units, where a supplemental supply will be furnished for a large acreage, the present canal system will be used, with such enlargements and additions as may be necessary to be made by the canal companies, to supply additional land under these systems with water.

Clinton District. This district is located on a branch of the Spanish Fork River, known as Thistle Creek, about two miles above the U. S. Reclamation Service diversion dam on Spanish Fork River.

Soldier Fork District. This district is located along Soldier Fork, a tributary of Spainsh Fork River, about fifteen miles from the U. S. Reclamation Service diversion dam on Spanish Fork River.

Diamond Fork District. This district is located along Diamond Fork, a tributary of Spanish Fork River, about seven miles from the U. S. Reclamation Service diversion dam.

The Project Manager is J. L. Lytel, with office at Provo, Utah.

CHAPTER XXIX

IN SIGHT OF THE SNOW-CAPPED "CASCADES." THE OKANOGAN PROJECT, WASHINGTON

Okanogan County was at one time a part of the Colville Indian Reservation, in the north central part of the state of Washington, and it was established as a county in 1887.

In 1886, that portion of the reservation lying west of the Okanogan and Columbia rivers had been thrown open to settlement. Flowing through the lands was Salmon Creek and from it the early settlers took water for purposes of irrigation. The first ditches were small, irrigating only a few acres for the raising of corn, potatoes, grain, hay and truck-gardens, but they demonstrated the value of irrigation, and in 1888, the ditches were enlarged and others constructed.

Owing to remoteness from markets, and because of the excellent range afforded, stock raising was very generally followed. The providing of winter forage made hay one of the principal crops to be grown on the irrigated tracts. The soil was found to be very fertile, and would produce from four to five tons of alfalfa, per acre.

Several small orchards were planted about this time, and these, with a few others planted later, have demonstrated the quantity and quality of apples and other fruit that can be grown in the Okanogan country, and have had much to do with the almost universal giving over of the project to the raising of fruit at the present time.

As the demand for hay increased, the irrigated tracts became larger, requiring more water. As a result, in the succeeding few years the normal flow of Salmon Creek was over-appropriated and during the last of each season a shortage occurred.

Foreseeing the litigation which was sure to follow this over-appropriation, and to provide storage for use during the low water period, a corporation, known as the Conconully Lake Reservoir Company, composed of many of the first appropriators from Salmon Creek, was organized on November 3, 1897, under the State laws. This company purchased or obtained easement for the necessary rights of way for canals and reservoirs, and by the construction of a small dam at the outlet of Salmon Lake (then known as Conconully Lake) were able to store 1,500 acre-feet of water to provide against the annual shortage during the low water period.

The source of water is Salmon Creek, heading in the Cascade Mountains, which has a drainage area of about 140 square miles. The annual run-off in acre-feet, from 1903 to 1915 was maximum, 56,500; minimum, 17,350; mean, 29,118. The rainfall on the irrigable area, a six-year average, was 12.28 inches, though in 1915 15.98 inches fell. The average elevation is 1,000 feet above sea level, and the temperature ranges from 10° to 105° Fahr. The length of the irrigating season is from May 1 to September 1, 123 days.

When the Reclamation Act was passed the Okanogan County Improvement Club petitioned the Secretary of the Interior to make this region one of the projects of the Service. After investigation this was done and a plan of irrigation laid out which provides for the storage of water in Salmon Lake and in Conconully Reservoir, controlled by Conconully Dam on Salmon Creek, about 2 miles below Conconully, Washington, the control of Salmon Lake Reservoir by a short inlet canal from Salmon Creek and concrete outlet works; the control of Conconully Reservoir by means of an outlet tunnel discharging into Salmon Creek below the storage dam; the diversion of water from Salmon Creek by a dam about 12 miles below the reservoir into a canal system watering lands in the valley of Okanogan River between Riverside and Okanogan, Washington. A pumping plant is also operated by power generated on the project when the gravity supply of water is not sufficient.

Salmon Lake is a narrow body of water 3½ miles long located on a tributary of the north fork of Salmon Creek. It is utilized to store water between elevations 2,282 and 2,298 feet above sea level. An inlet canal has been constructed from the North Fork of the Creek to the lake. The release of water from the reservoir is controlled by a simple concrete outlet structure, discharging into an outlet channel, which delivers the water into Conconully Reservoir, a short distance below. The area of Salmon Lake Reservoir is approximately 200 acres, and the capacity 3,200 acre-feet.

Conconully, the larger of the reservoirs, is located at the confluence of the North and West Forks of Salmon Creek, just below the town of Conconully, and was created by building an earth dam across the

Conconully Dam, with Spillway and Reservoir
Okanogan Project. Washington

creek bed. The area is approximately 460 acres and the capacity 13,000 acre-feet. The release of water is through a concrete lined tunnel, discharging into Salmon Creek, and is controlled by two 36-inch water works gate valves.

The height of the dam above the bed of Salmon Creek is 64 feet. Its top length is 1,010 feet, and bottom 815 feet. The dam was built of mountainside talus, varying from fine silt and sand through all sizes of angular stones to a cubic foot. This was moved and put into place by the hydraulic process, some of the water from the creek being used to carry the material into the flumes and pipes, and other water to wash it into place. It is regarded as an ideal dam. The coarse rock of both slopes is proof against attacks of wind, rain, or waves, and has no tendency to slough or slide, and furnishes free and safe outlet for any leakage or seepage through the dam. The core of fine material furnishes the necessary water tightness, having been thoroughly consolidated or packed by the treatment received.

The spillway has an overflow of 180 feet long, and is cut through the rock forming the right abutment of the dam.

The irrigable lands are part of a series of wide benches, which extend from the foot of the mountains to the river in the Okanogan Valley, from 30 to 40 miles above the junction with the Columbia River. Practically all the soil is light and porous, capable of producing the best of crops. Excellent range is afforded cattle by the lands bordering the irrigable area, but as the winters are severe it is necessary to feed the cattle during the time that wild forage is unobtainable. All the lands are in private ownership and the limit of land irrigated for one owner is 40 acres.

For drawing water from the reservoir a tunnel 6 x 6 feet, partly lined, is provided in the granite abutments at the east end of the dam. The normal discharge capacity is 500 cubic feet per second. The water when drawn out flows down Salmon Creek about 12 miles to the diversion weir, which is an ogee concrete structure with 50-foot length of overflow, which raises the water 4½ feet into a canal with a capacity of 110 cubic-feet per second.

Two miles below the head of the canal about 50 second-feet of water is dropped 110 feet to a lower bench, and two miles further down the upper canal another drop of 58 feet occurs. These drops are used for developing power used for pumping on about 1,070 acres of the lower lands. The water thus pumped is lifted from the Okanogan River and supplements the supply available from Salmon Creek. Each of these power-plants develops 187 kilowatts or 250 horse power on the switchboard, which is transmitted about five miles to the pumping plant near Omak. The pumping-plant and both power-plants occupy reinforced concrete buildings. While these plants undoubtedly will remain idle more seasons than they will be used, they will be indispensable in low-water years.

A part of the main canal through rock is lined with concrete for the purpose of economizing in excavation and for preventing percolation. A large part of the distribution system also is lined, in the portions selected for this being those parts located in sandy reaches where the seepage loss would be great without the lining.

The rotation method of delivery of water is followed, the user being allowed for seven days double the amount of water which would be required for constant flow, and then no water for the following seven days. This schedule is made reasonably elastic to meet special needs, but is adhered to as nearly as practicable and works out satisfactorily to all concerned.

When work on the project was first begun the nearest railway town was Wenatchee, 100 miles away. Water transportation, however, could be had 45 miles away, but to reach it settlers had to travel over poor mountain roads. In 1913 the Great Northern Railway constructed a branch line which reaches all the towns of the project, and thus affords an opportunity to reach outside markets. July 30 of that year saw great rejoicing when the first carload of apricots was shipped by the local branch of the Fruit Growers' Association. Later in the season eight carloads of apples were shipped together with six cars of the softer fruits, as peaches, apricots, etc. The great development that the railway's coming has furthered will be seen from the fact that in 1915 three hundred cars of apples, and ten of smaller fruits were shipped. Most of these shipments go to the Eastern States where the fine quality of the fruits bring prices large enough to justify the heavy freight charges.

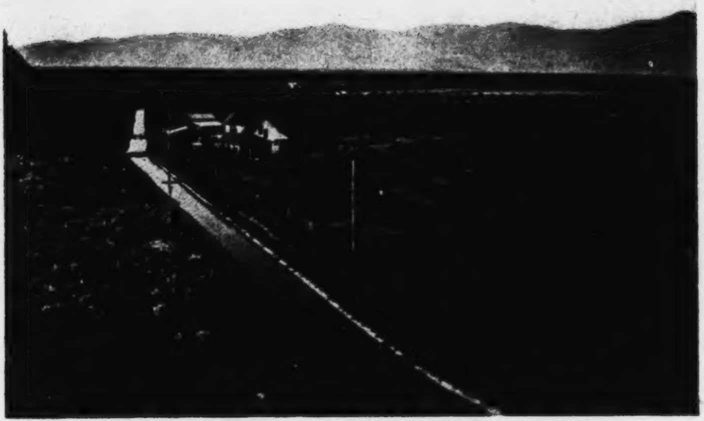
It is possible that before long the short railway gap that exists will be closed so that there will be a direct line from Oroville through the project to Vancouver, B. C.

Alfalfa is second only to fruit in its productiveness on this project. It is of excellent quality and brings good prices when sold, though the major portion of the crop is fed, mainly, to range cattle.

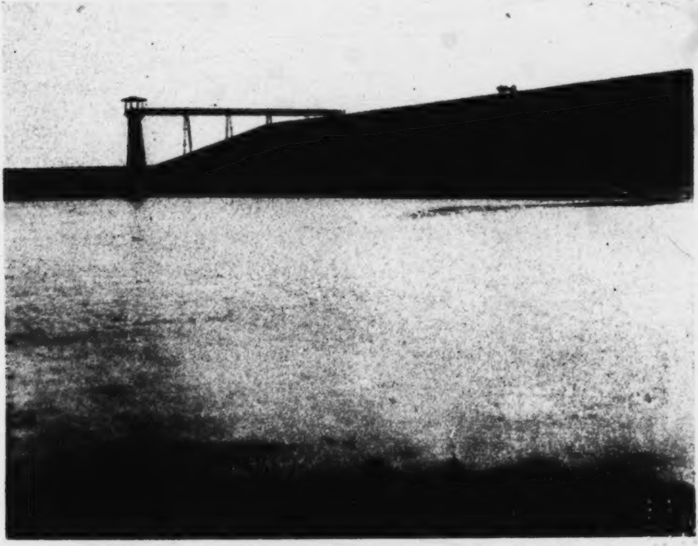
The total area of the project including all old water-right land and the 151 acres in the Town of Okanogan, is 10,099 acres. Of this total amount there is approximately 8,400 acres under the Government canal. The rest of the acreage falls under several small canals or ditches which divert from Salmon Creek, either above or below the Government diversion. The headworks of all of these private ditches were controlled by the Service during the year.

The number of farms irrigated on the project for the year was 458, with an area of 7,850 acres. The irrigable acreage of these farms is 8,450. The three towns contiguous to the project have grown, and the town of Okanogan, situated at the project's southern extremity, now has a population of about 1,000; the town of Omak situated near the centre of the project on the east side, has made some growth and has about 400 inhabitants. The town of Riverside, located near the northern extremity of the project, has a population of 200. This growth of the towns has been aided very materially by the Colville Indian Reservation being thrown open for settlement during the year 1916. This brought many new people into the country and resulted in considerable advertising of the project.

The towns of Omak and Okanogan have several women's organizations which are striving toward the betterment of social and moral conditions for the



Vista from Round Top Hill back of White Ranch
Okanogan Project, Washington



Cold Springs Dam, Reservoir, and Outlet Tower
Umatilla Project, Oregon

towns. The principal club, however, for the women of the project is known as the Country Club, to which a large majority of the farmers' wives belong. In 1916 it erected a temporary club-house, which will soon give way to a fine and permanent structure, which will be devoted to the general welfare of the women and children, as well as the men, of the surrounding country.

The orchards of the project in 1916 had a selling price of from $400 to $500 per acre, and unimproved irrigable land has been bought within the last two years for $75 per acre.

The settlers have had some difficulties of their own to contend with. Occasionally a hail storm or frost damages the young fruit, and grasshoppers are not unknown. In 1915 fire-blight made its appearance in the orchards, but a thorough and systematic pruning out of all the diseased wood has practically obliterated the infection.

To those who enjoy the marked variation of seasons the climate of this project is ideal. There is as distinct variation between spring and autumn as there is between winter and summer. The average elevation is high enough for health and comfort, the air is pure and clear, partaking of the vivifying and stimulating qualities of both ocean and mountain, and the blue sky of Washington is ever a delight to those used to the grey skies of the East.

The construction cost for the project has been fixed at $95.00 per acre, payable in 20 years without interest.

The present Project Manager is Calvin Casteel, with office at Okanogan, Oregon.

CHAPTER XXX

THE ARID BELT OF EASTERN WASHINGTON.

YAKIMA PROJECT, WASHINGTON

The State of Washington, though of comparatively recent admittance to the Union, bids fair to be one of the foremost in its wealth producing possibilities, and not the least of these is the development of its arid lands by irrigation. The climate is usually mild, though in the arid districts the temperature during the summer is generally high, a condition desirable for the growing of crops on irrigated land.

The Cascade Mountains, extending from north to south across the state, divide it into what are known as the East and West sides. The territory west of the Cascades, and extending well down on the east slope, is heavily timbered, with the exception of those portions which have been logged off. Over this territory the rainfall is abundant, the vegetation rank, and the forests of giant fir, cedar, spruce and hemlock unsurpassed. It is the natural moisture of this region which makes possible the irrigation of the lands in the dryer portions of the state mentioned below.

East of this timber belt and in the foothills of the less elevated portions of the eastern slope, is a strip of rough, rugged land, fairly well watered from winter snows and by mountain rains, which affords good grazing for cattle and sheep.

The arid belt extends from the eastern foothills of the Cascade Mountains to some distance east of the Columbia and Okanogan rivers, where the great wheat-producing belt commences, and extends to the Idaho line. This wheat land was originally covered with bunch grass, and, in its native condition, afforded most excellent range for cattle and horses. Today it presents a far different appearance, with its growing towns, fine country homes, splendid schools, highly improved roads, car lines, in fact, everything indicative of prosperity and progress. The pioneers of twenty or more years ago, who took up homesteads and endured the hardships and deprivations of the first lean years, are today wealthy ranchers with large land holdings, of which the original homestead is but a part.

The area included in what is known as the arid region has much the same soil as that which has proven so productive in the wheat belt, but owing to its location with reference to the Cascade Mountains, receives but little rainfall during the growing season, and unless artificially watered is practically valueless except for sheep range. It is, therefore, not surprising that with the many lakes and streams to supply water, the irrigation possibilities in Central and Eastern Washington have been especially convincing. Irrigation by private enterprise has been limited to comparatively small tracts, yet the total area thus irrigated is not inconsiderable, amounting, even as early as 1899, to approximately 135,000 acres, a large portion of which was located in Yakima and Kittitas counties.

The Yakima River is the largest of the streams taking source in the Cascade Mountains and flowing eastward to the Columbia through the arid section. The project for irrigation of the valley of the Yakima River, considered in its entirety, dwarfs every other national reclamation project. This valley is so vast in area, so varied in agricultural products, so diversified in its industries, so wonderful in its possibilities, that a complete presentation would require more space than the limits of this chapter allow. The more important features of the project for the watering of the dry lands in the valley will be considered as fully as space will permit.

The total length of the valley is nearly 200 miles, its width in places 15 miles, and of the land within its confines at least half a million acres are irrigable. For a great part of its length, the valley is narrow, almost to be called a canyon, but in places it broadens, forming broad, sheltered basins. It is the land in these fertile basins and on the benches above that affords such an opportunity for successful irrigation.

The Yakima Basin is separated from the watershed of the Columbia River on the north-east by the Yakima Ridge and the Rattlesnake Hills, barren and more or less rugged, with an altitude of 1,000 to 1,600 feet. On the south, it is shut in by the Horse Heaven Hills, in Benton County; while to the west it extends back from the river, with a gradual rise to merge, at varying distances, with the foothills of the Cascade Mountains. The main tributary streams come from the west, being fed by melting snows in the mountains. They flow through minor valleys or follow courses parallel to the numerous ridges which intercept, roughly at right angles, the general trend of the main valley.

Lake Keechelus Reservoir as seen from the Sunset Highway
Yakima Project, Washington

The water for the irrigation of the Yakima Project is secured from the Yakima River and its tributaries, which have a drainage basin of 3,550 square miles. It is estimated that with storage this water supply is sufficient for about 576,500 acres of land. The irrigation plan of the Reclamation Service provides for the storage of the flood waters of these streams in a series of five huge reservoirs near their headwaters, releasing therefrom into the stream beds when the natural flow becomes inadequate to the needs of the lands to be watered. The water is diverted by dams at various places down the stream, which turn the required quantities into the canals of the different distributing systems for delivery to the land. Besides these five storage dams, the project contemplates government construction of five great distribution units, in addition to which there are about 25 large systems owned by private stock-corporations and probably as many small ditches operated by individuals or communities.

The soil, generally speaking, is a volcanic ash or sandy loam with deep sub-soil, this being especially true of the bench lands; the lower lands, close to the rivers, to a large extent, are composed of gravelly sub-soil covered to depths varying from a few inches to several feet of sandy soil. These soils are all very fertile, and with water and cultivation their growing qualities are unsurpassed. The elevation above sea level of the irrigable lands ranges from 400 feet at the lower end of the valley to 1,600 feet in the vicinity of Ellensburg.

The temperature throughout the summer is usually high, especially during July and August, but owing to the dryness of the atmosphere, the heat is seldom oppressive and the nights, even in midsummer, as a rule, are agreeably cool. The winters are mild, the temperature seldom reaching zero. The average rainfall is considerably less than ten inches, ranging from six inches at Kennewick, in the lower valley, to eleven inches at Ellensburg, near the foothills.

The valley is traversed throughout its length by the main line of the Northern Pacific Railway, and for a portion of its upper length by the Chicago, Milwaukee and Saint Paul Railway. The lower part of the valley, including the North Yakima district, is also tributary to a branch of the Oregon-Washington Railroad and Navigation Company's lines. There are several small branches, including the North Yakima and Valley, (a subsidiary of the Northern Pacific), from North Yakima to Naches, Selah and Moxee; the Yakima Valley Transportation Company's street car system and interurban lines; and the Sunnyside Branch of the Northern Pacific Railway.

It will not be needful to present more than the briefest outline of the history of the valley. The first treaty with the Yakima Indians—then in undisturbed possession—was made in 1855. The first settler entered the valley in 1861. In 1865 Yakima County was created, portions of which have since been taken away to make Kittitas and part of Benton counties.

The beginnings of irrigation date back to as early as 1867, at which time the "Nelson Ditch" was constructed. This ditch, which is still in existence, was very small, carrying about seven cubic feet per second. Even with this small beginning, however, the advantages of irrigation were at once apparent, and water was appropriated and canals built from time to time until at the time of the passage of the Reclamation Act about 121,000 acres had been irrigated. In 1884, after seemingly interminable delays, the Northern Pacific Railway was built through the valley, and in 1890 commenced construction on the first great canal system in the state. The total length of the main canal was sixty miles, with 550 miles of branches and laterals, and the area irrigated was about forty thousand acres. This canal was later enlarged and rebuilt by the Reclamation Service, and is now known as "Sunnyside Unit."

From the coming of the railroad to the passage of the Reclamation Act, in 1902, a large number of canals were constructed with private capital, some of considerable size, but all under great financial difficulties, fierce litigation as to water rights, and numerous other vicissitudes. Several valuable projects were commenced by over-sanguine owners and some even reached advanced stages of construction, only to prove the financial ruin of their backers before they could be completed and successfully operated. Many miles of expensive canal were constructed, that have never carried a drop of water; acres of maps, plans and specifications were prepared to no purpose; and scarce an old settler in the valley but has his package of stock certificates in some abandoned irrigation scheme.

Therefore the passage of the Reclamation Act was hailed as a great boon by the people of this country, as it was hoped that through its agency the government would take over many of their burdens. Consequently, petitions were presented by land owners asking that various projects throughout the state be investigated with a view to their construction by the Government. These schemes were presented in their most favourable aspects, and urged with every method known to the resourceful promoter, so that the selection of the most favourable projects was made more difficult by the pressure brought to bear upon every official interested. The landowners in each locality advanced the merits of their particular scheme and cited disadvantages of every other; and the matter was only settled by making a thorough enough field-investigation of every project advanced to enable the engineers of the Service to determine the comparative merits of each scheme.

In the State of Washington five districts, ranging in size from 150,000 to a million or more acres, in addition to a considerable number of smaller areas, were brought forward for consideration, and, under instructions from the Secretary of the Interior, were carefully investigated to determine their feasibility and probable cost. It was found that while each presented some favourable aspects, there were in most cases engineering difficulties that would raise the cost to prohibitive figures, the final choice settling on the Yakima Valley as offering the greatest opportunity at the lowest construction cost.

The first steps toward actual construction of the Yakima Project were taken in 1905, when the engineers in local charge of the work commenced on the Tieton Unit. At the same time the purchase of the

Northern Pacific's rights on the Sunnyside Unit was decided on. From that time the activities of the Service in the valley have been continuous, and the results obtained have been such as to justify the most sanguine predictions.

In the early days every encouragement was given to the Service, to secure desired construction, but as the work advanced many critics arose. Disappointed contractors, engineers who had advocated rival schemes, disgruntled employés, and others continually sought for engineering errors or questions of judgment that might be criticized. Before construction, owners eagerly agreed to pay any cost that might be necessary, but later sales of land were made without this point being made clear to the purchaser, who, when the final costs were assessed, felt that he had a grievance against the Government because the costs were higher than some real estate dealer persuaded him to expect!

While it cannot be stated that the work of the Service was perfect, without error, or that money was never spent in an injudicious manner, in all respects, yet most of the criticism was without foundation, and a careful examination of the facts shows an enviable record of efficiency and economy.

The larger features of the Yakima Project have been constructed by Government forces. This has been due to two causes—first, failure on the part of contractors on the principal features let by contract to make satisfactory progress, necessitating the suspension of contracts and completion of work by the Government; second, various uncertainties in connection with the work, on account of the necessity of maintaining service through the canals during the time of construction.

It is interesting to note the economy resulting in a larger way from the permanent type of construction, which has characterized the activities of the Government. The Sunnyside Unit has now been operated by the Reclamation Service for ten years, and the Tieton Unit for over five years, and it appears that the annual charge necessary to maintain these two systems in a condition equal to that when new will be about $1 per acre and $1.35 per acre, respectively. At these rates it is believed that the systems can be maintained indefinitely without special levies for reconstruction of any portion of the system maintained by the Government.

Under private canals in the Yakima Valley, where all conditions are fully as favourable as for the government project, the original construction cost of which varied from $40 to $75 per acre, it has been found necessary within the past two years to reconstruct to a very large extent the main features of the canal systems, and two or three of the larger private canal companies in the valley have made expenditures for reconstruction which, including interest, will cost the landowners from $50 to nearly $100 per acre. In other words, the cheaply constructed private projects are now paying out for reconstruction more than the entire first cost per acre of the Tieton and Sunnyside units of the Yakima Project.

As to operation and maintenance costs, no private project in the valley is giving service value for the charge imposed equal to that under the Government

Diversion dam in Yakimi River, Headgates, and Gate Tender's house on the Sunnyside Canal
Yakima Project, Washington

Main Tieton Canal, Tieton Canyon, 600 feet above the stream
Yakima Project, Washington

project. Under private projects the almost universal practice is to deliver water at the bank of the main canal, at which point all obligations of the management cease. Under the Government project, distributaries have been built to each farm unit, and the water is actually delivered by Government employés to every landowner.

The flow of water in the mountain streams is greatest at the time of melting snow in the spring, during the months of February to June, but by the latter month the snow has practically disappeared from all but the most lofty peaks, and there being no rainfall in this region during the summer, the amount of water flowing in the streams decreases, until many of the smaller water-courses dry up entirely, and even the largest of the rivers are greatly reduced.

Most of the crops grown in this region require little or no water during the spring months. In many cases snow and rain fall on the lands during the winter, and by careful cultivation enough moisture can be conserved to start the crop and carry it for several weeks, but after that time, to secure proper growth, water must be applied every two to four weeks throughout the entire growing season. The frequency of irrigation depends upon circumstances of crop, soil, location, and many other conditions. But it may safely be stated that water must be applied at least once in June, twice in July, twice in August, and probably once in September. Thus we have high water in the streams during the spring when there is little need, and great need of irrigation in the summer when the water supply is low.

When the Service entered the valley this condition was already very bad for not only was the entire available summer flow used, but claims for many times this amount were being contested, and it was apparent that in order to irrigate additional lands, some of the early spring run-off must be held for use during the summer months. This idea, then, was the forerunner of the series of storage dams above mentioned, the building of which would alone have proved the great value of the Reclamation Act to the country.

Investigation of storage possibilities in the Yakima Valley revealed the presence of three large lakes at the head of the main river, and two other good sites on main branches, so the project includes the building of five dams to increase the holding capacity of these lakes and insure the valley against a summer water shortage.

Three of these dams have now been completed and a fourth is under construction, securing the irrigator against water famine in the dryest season. The water supply is now, in fact, considerably in advance of present distribution development, but future plans for the Indian Reservation contemplate immediate use of this extra water.

The land-seeker has a wide choice of climates within the Yakima Valley, for different conditions prevail in each district. The Kittitas Basin, nearest the headwaters of the river and highest in altitude, has a temperature ten to fifteen degrees cooler than in the vicinity of North Yakima. This district raises large crops of hay and potatoes for the Alaska markets; it is the home of the alfalfa grower, the general farmer, the dairyman; and while fine apples are grown here, fruit is not the main crop. The principal town of this district is Ellensburg, county seat, site of the State Normal School, and centre for two railroads. The markets of Alaska and the Orient are within easy reach through the cities of Puget Sound, and opportunities for the future of this section are very bright. Irrigation is secured by a number of small canals, although plans have been made for a large system, to be built under either the Reclamation Service or the District system to irrigate nearly 100,000 acres and furnish a more dependable water supply. This new system will undoubtedly be built in the near future, and will add greatly to the value of the lands thereabout.

The centre of interest in the Yakima Valley is the rich district surrounding the city of North Yakima. This belt, with its warm summers, mild winters, and fertile soil, is known throughout the world for the perfection of its fruit, of which the apple is the most important. The lands in the main valley are all fully developed, mostly in small tracts of less than twenty acres, and can be secured by the newcomer only at very high figures. The fruit business is, however, a precarious one, not to be followed by an inexperienced man with much hope of immediate success. It also requires considerable capital, but when intelligently handled the returns are often marvellous.

This district was quite well developed before the advent of the Service in the valley. It is served by a number of large irrigation systems, mostly owned by mutual stock companies. The common practice is that the ownership of the land and of the stock in the irrigation company shall be inseparable, each share of stock entitling the holder to a certain amount of water for his land. Since the building of the government storage dams, these private systems are assured of plenty of water.

There are several outlying districts, tributary to the main valley, such as Wide Hollow, Selah and Moxee Valleys. Originally planted to general crops, hay, grain, potatoes and pasturage, many of these lands have lately been set to orchards. Success does not always follow these ventures, as some variation in soil, temperature, or air drainage may make the location unsuitable for fruit growing, but in most cases good results follow. These lands, however, and the dry lands beyond them, are still the home of the "Big Yakima Potato," always a profitable crop.

The Tieton Unit of the Yakima Project occupies bench lands to the west of the main Yakima Basin, and about two hundred feet higher in elevation, and previous to the advent of the Service, the accessibility of this district, its rich soil, pleasant location and apparent ease of irrigation made it the coveted spot of the entire valley. Lower ditches, irrigating adjacent lands, had been in successful operation for many years, and the results stimulated speculators to try to reclaim the higher lands. Many canals were projected, some few located on the ground, and construction actually commenced on at least one, but so many difficulties arose in securing a sufficient supply of water and getting it on the ground, as well as in financing the project, that these attempts all failed.

The Tieton Unit as finally decided upon by the Reclamation Service engineers irrigates about 34,000 acres of these bench lands, using the waters of the Tieton River, which has a splendid all-the-year flow, in conjunction with those of Cowiche Creek, smaller and less dependable. To bring water to the land at a sufficient elevation, it was necessary to divert the waters of the Tieton River, several miles above its mouth, carry them in a flume high on one bank of the river, and, crossing the divide by tunnel, pour them into Cowiche Creek. The combined waters follow the natural bed of this stream until diverted at different levels into the several branch canals for distribution to the land.

The building of the main flume and tunnels was difficult, both because of the natural obstacles of the country and the inaccessibility of the location. For these reasons, and because of the comparatively small acreage watered, the construction cost per acre was high, but the natural advantages of the land are so great that the cost of water is fully justified. Many hardships were caused among the purchasers of land on the project however, by the exorbitant prices at which private lands were sold, for the excessive demands for principal and interest payments soon became irksome to the settler who had not yet brought his land to full production. This condition is rapidly passing now, and the settler, aided by the passage of the act which gives him twenty years without interest in which to pay for the water, and by the increasing value of his crops, has now reached a much better financial condition.

The elevation of the lands on this part of the project varies from 1300 to 2100 feet above sea level; winters are mild, with a few inches of snowfall, the temperature seldom dropping as low as 15° above zero. The growing season is long and warm, assuring abundant growth, but though the day temperature will often range in the nineties, the nights are pleasant with cooling breezes from the nearby mountains. The soil is volcanic ash, exceedingly fertile and particularly adapted to fruit growing. More than 8,000 acres have been planted to fruit trees, and as the project is new and the orchards not yet in full bearing, the custom of raising crops of grain, hay or vegetables between the tree rows is generally practised. There is a growing interest in diversified farming, shown by such activities as dairying, hog raising, and careful crop rotation. Hops are a valuable crop, and potatoes and onions grow to perfection.

The project is now well settled, no desirable homestead lands now remaining, but there are still good opportunities for purchase or lease, from private owners who are unable to develop their lands or cannot give them proper attention.

The Sunnyside Unit, in the next basin down the valley, has a still warmer climate. The lands under this unit consist of 102,824 acres lying in Benton and Yakima counties. The irrigation system, originally constructed by a private organization and developed by the Northern Pacific Railroad, was purchased by the Government and has been completely rebuilt and greatly enlarged. The average elevation of the lands is 800 feet above sea level, and the temperature ranges from 20° to 110° above zero. The soil is

After Four Years of the Reclamation Service
Yakima Project, Washington

deep volcanic ash and gravel, easily tilled and responding readily to irrigation. The principal products are forage, fruits and vegetables, dairy and poultry products. Growers of peaches and similar soft fruits meet with phenomenal success in this part of the valley, the climate being ideal for this crop. The markets are Washington cities, Alaska, and in the case of fruits the entire country and foreign markets.

Within the project limits are the following towns, situated along the two lines of railroad: Grandview, Sunnyside, Outlook, Granger, Zillah, Mabton, Byron and Prosser.

The cost of water right is $52 per acre. In 1916, 59,449 acres were cropped, the total crop yield amounting to $4,341,940, an average return of $73 per acre. It is an interesting fact that the gross returns for the project for the year of 1916 and for seven years previous annually exceeded the whole cost of construction of the project. The total acreage receiving water in 1916 was 73,000, more than 13,000 acres being in young orchards, young alfalfa, etc. Excellent raw land is to be had at $50 to $100 per acre, water right unpaid, and some rougher lands with paid-up water rights may be had at from $60 to $100 per acre. Improved land adapted to general farming brings from $150 to $200 per acre, and choice bearing orchards may be had at $300 to $500 per acre. There are splendid openings for by-product plants of various types, evaporators, canneries, creameries, cider, vinegar, alcohol and starch factories. Livestock and commission brokers are needed to ship in and distribute among the farmers in the fall cattle and sheep to be fattened for market, and to purchase and ship out in car lots the stock thus fattened; also to handle the increasing number of hogs and other animals.

Little can be said at this time in regard to opportunities on the Yakima Indian Reservation, across the river from the Sunnyside Unit. There is a large area of very fruitful land in this reservation and arrangements for its more profitable use will no doubt be made in the near future. It is planned eventually to irrigate 120,000 acres of land by ditches to be constructed in conjunction with the Indian Service, and much of this land will be sold off by the Indians for general settlement. Water for this irrigation is now available in storage dams already constructed.

Farther down the river, the irrigated lands continue to the junction with the Columbia, in the vicinity of the towns of Kennewick, Pasco and Richland. The greater warmth of this locality make it a marvellous producer of canteloupes, peaches, strawberries, and early fruits and vegetables of all sorts. Much of the surrounding lands are included in the contemplated Benton High Line Project, considered for later development. No work has yet been done in this district by the Reclamation Service, although many private canals are in use, taking water from both the Yakima and Columbia rivers.

The present Project Manager is R. K. Tiffany, with office at North Yakima, Washington.

CHAPTER XXXI

IN THE BIG HORN BASIN. THE SHOSHONE PROJECT, WYOMING

The world is familiar with the charms, fascinations, allurements, and unique wonders of the Yellowstone National Park. Its bubbling mud geysers, hot water geysers, gorgeously coloured terraces and rainbow hued pools and lakes are world-renowned, while "Old Faithful" is almost as well known as Niagara or the Mammoth Cave of Kentucky. Roaming in this region for countless centuries have been various tribes of Indians. One of these was known as the Shoshone—pronounced in three syllables, *sho-sho-nee,* with emphasis on the second syllable—but many who know the name and are familiar with the Indians, do not know the peculiar significance of the term. I do not give this as ascertained fact, for Dr. F. W. Hodge, in his comprehensive *Handbook of American Indians* makes no reference to it, but it is stated that the name originated as follows: One band of this tribe resided in a beautiful and secluded valley, some 75 miles to the east of the Yellowstone National Park, through which ran a charmingly pure and attractive river. Near its headwaters several hot springs and geysers were located. Some of these were sulphur and other supposedly healthful waters, which, however, "smelled to high heaven." But they were in great repute among the tribes of the region, who came and drank of their waters, and bathed in them, when sick, and went away full of gratitude to the "Powers Above" as well as the "Powers Below" who thus gave them such tokens of their goodness. On account of their strong odours these springs and geysers were called the "Shoshone," the *stinking waters*—and the river soon gained the same name, and when other and far away tribes spoke of the resident Indians, they called them also, the Shoshone. When, therefore, the pioneers of the West came into the land and asked the name of the river and were told, together with its significance, they with that direct and vigorous speech for which they will never be forgotten, openly designated the stream as the Stinking River, by which name it is still known on some of the United States maps. The Indians were proud of their health-giving springs and geysers, and of their river, and gladly accepted the name for themselves, by which they are known to this day. But the Wyoming legislature, by statute, changed the name to Shoshone River, although the sulphuretted hydrogen gases in the "stinking river" still rise to vex the nostrils. And the same name has been applied to one of the important projects of the Reclamation Service. This project contains a total of about 147,516 acres divided into four divisions as follows: Garland, 43,616 acres; Frannie, 41,000 acres; Willwood, 19,600 acres; Highline, 43,300 acres. Of these, the Garland Division is the only one at present open to homestead entry. This division contains a total of 650 farm units, ranging in size from 40 to about 80 acres, and of this number only 10 now remain unentered.

The major portion of the lands are light sandy and clay loams, and the principal products are alfalfa, grain, sugar beets, vegetables, and small berries. Cattle and hogs also thrive well.

These are the lands that the Shoshone Project is designed to serve. The source of water-supply is the Shoshone River, which has a drainage area of 1,380 square miles. The annual run-off between 1903 and 1914 in acre-feet was, maximum, 1,420,000; minimum, 913,150; mean, 1,151,292.

In 1916 the acreage the Service was prepared to serve was 42,665 acres. The length of the irrigating season is from April 20 to October 20, 180 days. The average elevation of the irrigable area is 4,500 feet above sea level, and the average annual rainfall, for the years 1907–1914, 5.58 inches. The temperature ranges from 31° Fahr. below zero, to 101° Fahr., though it is only rarely and for a short time it reaches these extremes. Every one familiar with the climate, winter or summer, knows that it is healthful and enjoyable, though it certainly grows cold in winter and warm in summer. The high elevation, however, destroys humidity, and sunstroke and heat prostrations are unknown. The valley, being completely surrounded by mountain ranges seldom experiences what might be called a severe storm, and the days during the summer, no matter how high the thermometer ranges, are never oppressive or sultry, and the nights are of that clear, cool character, that soothes and yet vivifies.

When one recalls that he is within a day's horseback ride, or buggy drive, of some of the finest big game hunting yet to be had on the American Continent, and that he is within an easy day's automobile ride of the wonders of the Yellowstone he feels that he has a playground close at hand in which he may find relief from the most arduous of labours. A week's camping-out trip is an ideal vacation anywhere in tree-clad mountains, but to be able to take one's family and enter the incomparable park of the geysers and paint-pots, obsidian cliff and glorious terraces found in the Yellowstone, is to be favoured above ordinary mortals. Good roads are found on every hand on the project, and in the Yellowstone National Park the roads are kept in perfect condition by the Interior Department.

The water used for irrigating this project is diverted from the Shoshone River, which is fed by streams having their headwaters in the Yellowstone National Park at altitudes between 7,000 and 10,000 feet. This river rises in the interior of Wyoming and runs northeasterly into the Big Horn. About 60 miles from its head it emerges from the mountains into a small valley, where it is joined by its principal tributary, the South Fork, and then cuts through an abrupt granite spur, beyond which the country opens out into the form of a terraced plain, through which a canyon conducts the river on its way. The geological indications are clear that many centuries of centuries ago, a few miles above this plain, there existed a vast and beautiful lake, fed by springs from the snow and glacial fountains of the mountains that surrounded it. Between it and the valley a range of lofty mountains intervened. When the lake overtopped its banks the overflow, passing through some cleft or crevice in

Shoshone Dam
Shoshone Project, Wyoming

the mountain range, during centuries of time slowly chiseled and carved out a canyon eight miles long and hundreds of feet deep. Little by little the volume of water in the lake was lowered and the canyon became deeper and wider. When civilized man came upon the scene science and skill were called upon by imagination which said: "Build a gigantic dam in that gorge, and restore to the face of nature the exquisite lake that, centuries ago, she lost." This was part of the work the engineers of the Reclamation Service set themselves. In addition, they contemplated the diversion of water from the Shoshone River by a dam at Corbett, about 16 miles below the reservoir, building a tunnel which should convey the water into a canal system supplying the lands on the north side of the river in the vicinity of Ralston, Powell, Garland, Mantua, and Frannie. They also planned to divert water into the Willwood Canal for the irrigation of lands on the south side of the Shoshone River; and the diversion into the north side High Line from the Shoshone Dam for the irrigation of lands lying on the north side of the Shoshone River above the Garland Canal system and extending from the lower end of the Shoshone Canyon, near Cody, to the divide between the Shoshone River and Clarks Fork drainage.

While in the pioneer days successful irrigation was carried on from the river, the natural flow was insufficient for the vast area still untouched. Any considerable enlargement of the irrigable area was possible, or at least practicable, only when adequate storage facilities had been provided. It was this that led to the erection of the dam in Shoshone Canyon. The work was difficult and dangerous. Men were lowered into the gorge, and with ropes around their bodies did the necessary drilling and blasting on the walls, which are hundreds of feet high.

Before work could be begun on the structure itself it was necessary for the Service to build a rough trail, 8 miles long, which it afterwards developed into a fine wagon-road, for the conveyance of drills, hammers, shovels, powder, and all the needful supplies for an active, busy, bustling camp. Two tunnels were built for the road between Cody and the dam-site, and the site itself was passed by a tunnel above the left abutment. This road was continued westward up the North Fork of the Shoshone River to serve as a road to Yellowstone Park and to replace the road formerly used and submerged by the reservoir. The precipitous location necessitated several tunnels on this road extension.

The design of the Shoshone Dam is closely related to that of the Pathfinder Dam on the North Platte Project, both being high structures in narrow granite gorges. It is the result of studies made by John H. Quinton and George Y. Wisner, and is a compromise of different plans, finally formulated by a board of engineers appointed for the purpose.

It has a top thickness of 10 feet, with a batter to stream-bed of 15 per cent on the reservoir face, and of 25 per cent on the down-stream face. Both faces are made vertical below stream-bed. The axis is curved to a radius of 150 feet, forming an arch upon which the dam depends for stability. It is of concrete, made of sand and gravel of good, sound granite. Rocks weighing from 25 to 200 pounds are embedded to at least 25 per cent of the total volume.

A tunnel, 500 feet in length, 10 feet square in section, was provided through the right abutment for the primary purpose of diverting the river during construction, and afterward employed for drawing water from the reservoir. Another tunnel, 20 feet square, on a ten per cent grade, entered by a concrete lip west of the dam, was designed to serve as a spillway.

Work was begun by contract in October, 1905. The diversion tunnel was excavated, and preparations were made for diverting the river into it by building a temporary diversion dam and a wooden flume to connect this dam with the tunnel. In May, 1906, work was stopped by high water, and on June 13 the largest flood of the season brought down a vast number of heavy saw-logs which greatly injured the temporary dam and destroyed the flume. This practically ruined the contractor, and the work was completed the following year by a new company. But again, this time in July, came a flood which reached a discharge of 14,000 cubic feet per second, and, breaking a saw-log boom some miles above, released a number of logs which came down like battering rams and wrecked the temporary dam a second time.

At the subsidence of the flood the temporary dam was rebuilt and concreting in the base of the permanent dam was begun March 30, 1908, but on April 11 the pit was flooded by a freshet and work again stopped. Again in May the flood-period began in good earnest and work ceased entirely until August, when it was found that the foundation pit had been filled with river gravel, sand, and mud. Again it was excavated, a month being required to accomplish the task, and concreting was begun again and carried on so vigorously that by the end of November the entire base of the dam was well above the riverbed. The winter caused another delay. March, 1909, saw work resumed, and when the usual summer floods came they poured to a maximum depth of seventeen feet over the dam without causing any injury.

Concreting was resumed Sept. 1, 1909, and continued with various delays until January 16, 1910, which saw its completion. This winter was of such unusual severity that it was necessary to protect the concrete from frost by covering it with a huge tent which was heated with a system of steam pipes. These were indispensable, but greatly hampered the work and materially added to the expense.

All of these difficulties, together with the extremely contracted room for operations in the narrow gorge, the great depth to foundation, and the large and fluctuating volume of water to be handled, combined to make the construction of the Shoshone Dam hazardous and expensive.

The lowest outlet from the Shoshone Reservoir consists of two cast-iron pipes, each 42 inches in diameter, laid radially through the dam, imbedded in the concrete about the low water elevation of the river.

Each project of the Service presented to the engineers its own problems for solution. We have already seen some of those met and overcome in the building of the Shoshone Dam. In the planning of the necessary distribution works the problem to be met was caused by the peculiar "lay of the land" to be irrigated. The Shoshone Valley consists of a series of terraces rising higher and higher above the bed of the river, which flows in a canyon, cut in the gravels which form the terraces. Any diversion from the river, therefore, must be either by means of a high dam or a long tunnel built on a gradient less than the general slope of the benches. There being no suitable site for a high dam at the proper location, the tunnel method was the one adopted.

Water released from the Shoshone Reservoir flows down the river sixteen miles to the Corbett Diversion Dam, where it is taken into a tunnel about three miles in length, which emerges into the Garland Canal. This dam is of hollow reinforced concrete, consisting of an inclined deck resting on buttresses. Its total height, including a two-feet concrete platform, is eighteen feet, and its length between abutments 400 feet. The right abutment joins an embankment 450 feet in length, reaching to the bluff and standing eight feet above the masonry of the dam. At the left abutment are located a sluiceway and the head-works controlling the entrance to the Corbett Tunnel.

About twelve miles below this tunnel the main canal crosses a drainage line near Ralston, and here is found a reservoir of 2,100 acre-feet capacity to regulate the flow in the main canal. It also furnishes a domestic water-supply to the towns of Ralston and Powell.

The Shoshone Project was built under the general direction of H. N. Savage as Supervising Engineer. The construction of Shoshone Dam was under the immediate direction of D. W. Cole.

Up to the present time it has not been necessary to make any large use of stored water for irrigation purposes, the normal flow of the river being sufficient for all requirements. However, when the entire project is under constructed works, and the lands cultivated and irrigated, stored water will be necessary, and for this reason the Shoshone Dam was constructed.

Future work on the Shoshone project contemplates the construction of the Highline Canal, the Willwood Canal, and the extension of the Frannie Canal to cover lands in the vicinity of the town of that name, in Wyoming, now practically completed.

The Willwood Division, lying on the south side of Shoshone River, will be irrigated by a main canal twenty-one miles in length, taking water from the Shoshone River about seven miles below Corbett Dam. Water will be diverted directly into the canal without the aid of a dam. There are several points where it will be necessary to drop the water in the canal distances of from 25 to 40 feet, and it is proposed to take advantage of these drops and develop the electrical energy which will be used in pumping water to adjacent lands, which can not be reached from the gravity canal.

The Highline Division will probably be the last to be constructed. The present plans contemplate a canal through Shoshone Canyon for a distance of three miles, about two miles of which will be located in tunnel. The line then turns in a northerly di-

Shoshone Reservoir at Sunset, from 1000 feet west of Dam
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